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THE HISTOLOGICAL BASIS OF ADAPTIVE SHADES AND COLORS IN THE FLOUNDER PARALICHTHYS ALBIGUTTUS

⁂

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⁂

Contribution from the United States Fisheries Biological Station, Beaufort, N. C., and the Anatomical Laboratories of the St. Louis University School of Medicine

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THE HISTOLOGICAL BASIS OF ADAPTIVE SHADES AND COLORS IN THE FLOUNDER PARALICHTHYS ALBIGUTTUS.

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By ALBERT KUNTZ, PH. D.

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Contribution from the United States Fisheries Biological Station, Beaufort, N. C., and the Anatomical Laboratories of the St. Louis University School of Medicine.

INTRODUCTION.

Changes in shade, color, and pattern which, as is well known, occur in many bony fishes are due primarily to changes in the distribution of the pigment granules in the chromatophores in the skin and changes in the relationships of the guanophores (cells containing guanin crystals) with these chromatic organs.

The present investigation [a] is an attempt to determine as accurately as possible the behavior of the chromatophores and other elements involved in the production of color in the skin of the flounder *Paralichthys albiguttus*, as it undergoes changes in shade or color or simulates as nearly as possible the color of a given background.

MATERIAL AND METHODS.

The material used in this investigation consisted of a large number of specimens of *Paralichthys albiguttus* ranging from 10 to 30 cm. in length. Many of these specimens were kept in aquaria of chosen colors continuously for three weeks or longer, others for briefer intervals.

Observations were made largely on living and fresh material. Sections of preserved skin were used primarily for the study of the distribution of pigment in the deeper layers of the skin and the relationships of the color producing elements with each other and with other structural elements in the skin in a vertical plane.

The chromatophores and guanophores lying immediately beneath the epidermis can be observed very satisfactorily on detached scales on which the epidermis remains intact. The removal of a few scales, if done carefully, causes little or no reaction on the part of the fish, and, consequently, no changes in the distribution of the pigment in the chromatophores. If these scales are mounted in sea water, no changes in the distribution of pigment granules occur for a considerable interval. When preparations of the whole skin were desired, the fish was killed instantaneously by chopping off the head with a single blow. Fish killed in this manner usually undergo no observable changes in shade or color for some little time. Preparations of the skin studied immediately after this operation show essentially the same distribution of the pigment granules in the chromatophores lying immediately beneath the epidermis as do the scales removed from the living fish. There is, therefore, probably no immediate change in any of the chromatophores in the skin. The chromatophores and guanophores in the deeper layers of the skin were studied in sections and also directly in pieces of skin from which some of the scales had been removed.

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[a] This investigation was undertaken at the suggestion of Dr. S. O. Mast as a sequel to his work on "Changes in shade, color, and pattern in fishes, and their bearing on the problems of adaptation and behavior, with especial reference to the flounders *Paralichthys and Ancylopsetta.*" Bulletin of the United States Bureau of Fisheries, vol. XXXIV, 1914, p. 176–238. *Paralichthys albiguttus* was selected because it was found by Dr. Mast to be highly adaptable to backgrounds of various shades and colors and was used extensively in his work. The author is indebted to Dr. Mast, also, for helpful suggestions and reading the manuscript.

Skin desired for sectioning was fixed in Zenker's fluid, dehydrated as rapidly as possible, and immediately embedded in paraffin. The melanin pigment being very stable is not dissolved nor does it undergo any observable change in distribution during this process. The xanthine pigment being readily soluble in alcohol is completely dissolved. In the deeper layers of the skin the xanthophores can still be observed in sections; in the superficial layers they can not be distinguished from the guanophores which are closely associated with them. The guanophores remain intact and can be observed quite satisfactorily.

Skin desired for the study of the nerve supply to the chromatophores was prepared by the pyridine-silver method.

STRUCTURE AND DISTRIBUTION OF CHROMATOPHORES AND GUANOPHORES.

The skin of *Paralichthys albiguttus* contains chromatophores of two distinct types, viz, melanophores and xanthophores. The former contain melanin granules which vary in color from dark brown to black; the latter contain xanthine granules which vary in color from yellow to orange. Chromatophores of both of these types occur as isolated chromatic organs. Xanthophores are in many instances partly covered by overlying melanophores; however, chromatophore combinations involving a xanthophore and a melanophore, as described by Ballowitz (1913) in several species of teleosts, probably do not occur in this species. The melanophores are more numerous than the xanthophores. The averages of a large number of actual counts of the melanophores and xanthophores, respectively, in a given unit area in the superficial layer of the skin in nine specimens indicate a numerical ratio of melanophores to xanthophores in the layer immediately beneath the epidermis of 32 to 19.

A chromatophore consists essentially of a group comprising several or many pigment cells so arranged that the entire body presents a central area from which elongated processes radiate. In *Paralichthys* the melanophores are more nearly symmetrical and show a larger number of radial processes than the xanthophores.

A chromatophore is said to be "contracted" when the pigment granules are concentrated in the central area and "expanded" when the pigment granules are widely distributed. The terms "contracted" and "expanded" will be used in this paper in the sense here indicated and not with reference to the state of retraction or extension of the radial processes of the chromatophores.

A fully expanded melanophore (fig. 1, pl. 1) usually presents a relatively pigment-free central area bounded by a pigmented zone from which elongated pigmented processes radiate. Within the radial processes the pigment granules are usually disposed along more or less definite radial lines. Not infrequently radial processes show a dendritic structure; in other instances they are distinctly broader distally than proximally.

In a fully contracted melanophore all the pigment is concentrated in the central area. A fully expanded xanthophore (fig. 2, pl. 1) may or may not show a pigment-free area at the center. The central pigmented area is usually more or less irregular in outline and from it relatively few irregular processes radiate. The pigment granules show no regular arrangement. Xanthine granules disposed along definite radial lines are rarely observed. In a fully contraced xanthophore the pigment is all concentrated in a more or less irregular mass in the central area. Both melanophores and xanthophores can be observed in any phase intermediate between maximal expansion and maximal contraction.

Guanophores are cells or groups of cells which contain guanin in the form of minute crystals. They occur either isolated or in groups and are frequently associated, more or less intimately, with chromatophores. Guanophores are sufficiently abundant in the superficial layers of the skin to occupy a relatively large part of the surface area. They also possess the capacity to contract and expand to a certain degree. When a fish changes from a darker to a lighter shade more or less rapidly, the guanophores occupy less of the surface area and appear somewhat more compact in the latter than in the former condition. The number of guanophores in the superficial layer of the skin apparently varies somewhat with the shade assumed by the fish if that shade is maintained for a sufficient length of time. In a fish which has for some time assumed a very light shade the guanophores in the superficial layers of the skin are sufficiently abundant to occupy a very large portion of the surface area. In a fish which has for some time assumed a darker shade the guanophores in the superficial layers of the skin are apparently less abundant. Conclusive evidence on this point could not be obtained. Attempts at counting the guanophores in a given unit area are unsatisfactory because individual guanophores can not always be recognized. On the other hand, the degree of expansion of these bodies and their particular spacial relationships with the chromatophores are important factors in determining how large a portion of the surface area shall be occupied by them. Relatively few guanophores occur in the deeper layers of the skin.

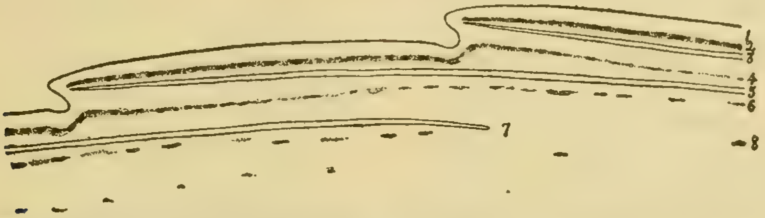

Fig. 1.—Diagrammatic drawing illustrating the distribution of chromatophores and guanophores in a longitudinal section of the skin of *Paralichthys albiguttus*. (1, epidermis; 2, 4, layers of chromatophores and guanophores superficial to scales; 3, 5, 7, scales; 6, 8, chromatophores and guanophores in the deeper layers of the skin.)

The chromatophores and guanophores in the superficial layers of the skin are located superficial to the scales. The corresponding layers of these bodies, therefore, imbricate with each other as do the scales (text fig. 1). Both chromatophores and guanophores are more closely aggregated over the distal than over the proximal area of the scales. Consequently, they are most numerous over the area of each scale which is intimately covered by epidermis. Furthermore, the chromatophores in these areas differ somewhat in size and form from those nearer the proximal ends of the scales. Those lying superficial to the proximal areas of the scales and, consequently, beneath the overlapping areas of other scales, are characterized by relatively few irregular long and slender radial processes. Over the distal areas of the scales the majority of the melanophores lie immediately beneath the epidermis. In these areas, as well as over the proximal areas of the scales, the xanthophores lie somewhat deeper than the melanophores. Many of the guanophores lie at the level of the melanophores, while others lie somewhat deeper.

Relatively few chromatophores occur in the deeper layers of the skin. In many instances they are closely aggregated around blood vessels in the corium and in the subcutaneous tissue. However, these chromatic organs in the deeper layers of the skin are probably too few and too far removed from the surface to play any important part in the shade or color assumed by the fish.

DEVELOPMENT AND DEGENERATION OF CHROMATOPHORES.

In surface preparations, as well as in sections of the skin, distorted and fragmented melanophores are not infrequently observed between the cells of the epidermis (text fig. 2), sometimes actually protruding from the surface. Doubtless these melanophores are being eliminated through the epidermis. This phenomenon was observed in the majority of the specimens examined, regardless of their shade or color. It was quite as common in specimens which were newly taken as in those which had been kept in aquaria for shorter or longer periods. Obviously the elimination of melanin pigment, and also its more or less continuous production, must be looked upon as normal physiological processes. A similar elimination of xanthine pigment through the epidermis was not observed. However, this negative observation affords no evidence that xanthine pigment is not eliminated in this manner. Xanthine pigment is highly unstable and would soon disintegrate following the fragmentation of the xanthophores.

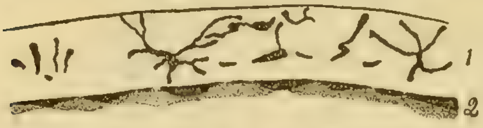

FIG. 2.—Camera lucida drawing showing fragmented melanophores between the cells of the epidermis. (1, epidermis; 2, layer of chromatophores and guanophores just beneath the epidermis.)

When a fish undergoes a change from a darker to a lighter shade and maintains that shade more or less constantly, a material reduction in the number of melanophores in the layer just beneath the epidermis takes place. Averages of a large number of actual counts of the melanophores in this layer in a given unit area of the skin of specimens newly taken or adapted to dark backgrounds and of specimens adapted to a white background indicate a reduction in the latter of approximately 30 per cent in the number of melanophores in the superficial layer of the skin. The rate at which this reduction took place in a single specimen which was placed on a white background as soon as it was brought into the laboratory is indicated by the curve *ab* in the accompanying figure (text fig. 3). This curve is based on the averages of a large number of actual counts of the melanophores in a given unit area on the surface of detached scales taken from various parts of the body. The figures in the vertical line indicate the number of melanophores in the given unit area, those in the horizontal line indicate the number of days following the initial counts. The initial counts were made when the fish was placed on the white background. This curve shows, furthermore, that a maximum reduction of approximately 28 per cent was reached in 11 days and that following this period the number of melanophores in the superficial layer of the skin remained fairly constant while the fish remained on the white background.

The averages of counts made on specimens which had been kept on a white background for a period of two months show, approximately, the same number of melanophores per unit area in the layer just beneath the epidermis as was shown by the counts made on the specimen used in the above experiment after it had been on the white background for a period of 11 days. It is probable, therefore, that when a fish becomes adapted to a background of a very light shade a maximum reduction in the number of melanophores in the superficial layer of the skin takes place in a relatively short time, and that little or no further reduction occurs even though a light shade is maintained for a prolonged period. This conclusion is supported by observations made by H. S. Willis on specimens which had been kept on given backgrounds for six months or longer.[a] This observer made camera lucida drawings under low magnification including all the chromatophores in the layer just beneath the epidermis on detached scales taken from various parts of the body. The averages of actual counts of the number of melanophores per unit area in these drawings indicate that melanophores are approximately equally abundant in the superficial layer of the skin of specimens adapted to black, blue, and red backgrounds and also of specimens adapted to white and yellow backgrounds. However, the average number per unit area in the drawings taken from specimens adapted to white and yellow backgrounds is only, approximately, 70 per cent of the average number per unit area in those taken from specimens adapted to black, blue, and red backgrounds. The difference here indicated in the number of melanophores per unit area in the superficial layer of the skin of specimens which had assumed dark and light shades, respectively, for a relatively long period is not appreciably greater than the corresponding difference indicated by the observations recorded above on specimens which had assumed dark and light shades, respectively, for relatively short periods.

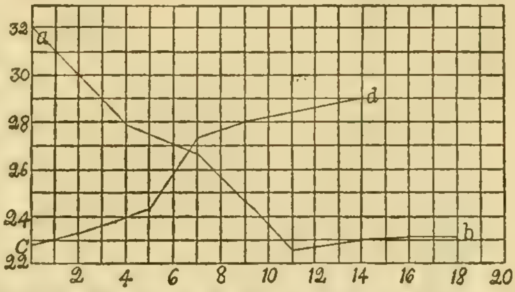

FIG. 3.—Curves showing the rate of change in the number of melanophores in the layer just beneath the epidermis. (For explanation, see text.)

When a fish in which the number of melanophores in the superficial layer of the skin has become reduced in response to the continued stimulus of a light background is transferred to a dark background, the number of melanophores in the superficial layer of the skin is gradually restored. The rate at which this restoration took place in a single specimen is indicated by the curve *Cd* in the accompanying figure (text fig. 3). This specimen was kept on a white background for four weeks and then transferred to a black background. The curve is based on the averages of 10 actual counts of the melanophores in a given unit area on detached scales taken from various parts of the body. Counts were made when the fish was transferred from the white background and at intervals of two or three days following this date. At the end of two weeks, when the experiment was discontinued, the number of melanophores per unit area was still somewhat less than the average for dark-colored specimens.

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[a] These observations were made under the direction of Dr. S. O. Mast and are used here with his consent.

CHANGES IN DISTRIBUTION OF PIGMENT IN CHROMATOPHORES.

Changes in the distribution of the pigment granules in chromatophores have been studied by many investigators in both invertebrate and vertebrate animals. Nevertheless, the manner in which these changes are brought about remains a controverted question. Two theories prevail at present. According to the one, the chromatophores contract and expand in an ameboid manner. Among the supporters of this theory may be mentioned von Wittich (1854), Busch (1856), Leydig (1857, 1873), Hering and Hoyer (1869), Pouchet (1876), Halpern (1891), Ehrmann (1892), Ficabli (1896), Verworn (1909), Fröelich (1910), Holmes (1913), and Hooker (1912, 1914). According to the other theory, changes in the distribution of the pigment do not involve essential changes in the form of the chromatophore, but the pigment granules move through the protoplasm or in fixed canals in it. Among the supporters of this theory may be mentioned Brücke (1852), Harless (1854), Virchow (1854), Lister (1858), Solger (1889), Biedermann (1892), Zimmermann (1893), Keeble and Gamble (1905), Kahn and Lieben (1907), Winkler (1910), Degner (1912), Ballowitz (1893, 1912, 1913, 1914), Franz (1908, 1910), and Spaeth (1913).

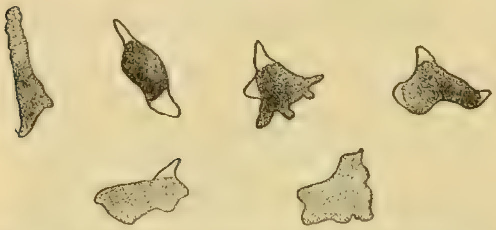

FIG. 4.—Camera lucida drawings taken at approximately 10-minute intervals of a pigment cell in an embroyo of *Lucania parva* 40 hours after fertilization. The stippled areas show the distribution of the pigment.

That it is quite impossible in fresh preparations of the skin or in living fishes to observe the limits of the processes radiating from the central area of a mature chromatophore except in its fully expanded condition is the common experience of not a few observers. That individual chromatophores possess a more or less definite form and that this form is retained, i. e., the position of each radial process remains apparently fixed, after repeated so-called "contractions" and "expansions" has been observed by many investigators. Therefore, if the processes radiating from the central area of a chromatophore are in turn retracted and extended, they must be composed of relatively fluid protoplasm and occupy more or less definite tissue spaces. That such is the case is maintained especially by Fröelich (1910) and Hooker (1914).

In isolated cells of the larvæ of *Hyla remolla* and *Diemyctylus torosus* containing black pigment Holmes (1913) observed unmistakable ameboid movements. While he admits the possibility that in the adult the cell processes of the chromatophores may be more fixed in outline, he still maintains that the extent to which ameboid movements occur in the pigment cells of larvæ ought to suggest skepticism as to the commonly accepted view that the pigment moves within the cell.

That ameboid movement occurs in the pigment cells of larval fishes is well known. The accompanying figure (text fig. 4) shows a series of camera lucida drawings taken at approximately 10-minute intervals of a cell containing yellow pigment in an embryo of *Lucania parva* 40 hours after fertilization.

The unshaded areas in these drawings illustrate areas free from pigment. The behavior of the pigment in the early pigment cells in embryos of this species is described by the writer as follows:

> The pigment granules arise in the central region of the cell and gradually push out toward the periphery. Until pigment is present in all parts of the cell the parts free from pigment remain clear.

> Even after pigment has been present in all parts of the cell it may become concentrated in the central region leaving the peripheral region clear. In many instances as the pigment becomes concentrated isolated granules or groups of granules remain far out in the protoplasmic processes. The concentration and redistribution of pigment granules are obviously not due to ameboid movements of the cell, but to movements of the pigment granules in the cytoplasm.[a]

This description applies both to the cells containing yellow and those containing black pigment. It is in full accord with the findings of Franz (1908) in larvæ of *Pleuronectes platessa.*

While pigment cells in fishes are distinctly ameboid during embryonic and larval development, changes in the distribution of the pigment within them are probably not due to the form changes of the cells alone. If this were the only factor involved, we should expect that after pigment is once present in all parts of the cell the entire cell would remain pigmented regardless of its changes in form. The outlines of these cells are easily observed in early larvæ and, as indicated above, pigment-free areas arise after pigment has been present in all parts of the cell. On the other hand, changes in the distribution of the pigment granules frequently occur when no changes in the form of the cell are taking place. Therefore, the conclusion that changes in the distribution of the pigment granules in the chromatophores of larval fishes are due to ameboid form changes in the cells alone is unwarranted.

The functional activities of chromatophores were studied in considerable detail by Dr. S. O. Mast and the author in living specimens of *Paralichthys albiguttus.*[b] This species lends itself admirably to work of this kind. Specimens 5 to 10 cm. in length were used which had been kept in aquaria for some time and had been repeatedly transferred from one background to another of a different shade or color. They were consequently accustomed to handling and responded very promptly to changes in the shade or color of the background. A compound microscope was submerged in an aquarium containing water deep enough to cover a small flounder resting on a glass plate on the stage. The flounder was orientated so that the microscope could be focused on chromatophores in the caudal fin. When a white cardboard was placed under the glass plate and beneath the head of the fish the latter assumed a whitish shade. When the white cardboard was replaced by a black one the fish very promptly assumed a very much darker shade. These changes in shade took place so rapidly that the movements of the pigment granules in the melanophores in the field of the microscope could be observed quite satisfactorily even under high magnification.

As the fish assumed a light shade in response to the white background, the pigment granules in many of the melanophores in the field of the microscope could be seen retreating from the peripheral portions of the radial processes along more or less definite radial lines and becoming concentrated in the central area. As the fish assumed a darker shade in response to the black background, the pigment granules in the same melanophores could be seen advancing peripherally apparently along the same radial lines. Occasionally as the pigment granules advanced peripherally or retreated toward the center the radial lines would break, leaving spaces free from pigment granules. These spaces remained open for a short time and then gradually became filled by advancing or retreating granules. No evidence of the retraction and extension of the radial processes of chromatophores could be observed. Rythmical movements consisting of alternating short advances and retreats of the pigment granules lying nearest the peripheral ends of the radial processes of melanophores were observed in fish resting quietly on a background to which they were thoroughly adapted. Again, not infrequently movements of pigment granules resembling Brownian movements were observed at the peripheral ends of the pigment masses extending into the radial processes of moderately expanded melanophores in resting fish. Such movements are characterized by Ballowitz (1913) as "a remarkable dance."

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[a] Bulletin Bureau of Fisheries, vol. XXXIV, 1914, p. 419.

[b] These observations were made at the United States fisheries biological station, Beaufort, N. C., during the summer of 1914.

Changes in the distribution of the pigment granules in the xanthophores take place in essentially the same manner as in the melanophores. In these chromatophores pigment granules could be observed advancing toward the periphery and again retreating, but not along well-defined radial lines. In general the movements of the xanthine granules are more sluggish and less regular than those of the melanin granules.

The above observations on the behavior of the chromatophores in living specimens of *Paralichthys albiguttus* as they undergo changes in shade or color lead us to conclude that changes in the distribution of the pigment granules in the chromatophores do not involve essential form changes in these bodies, but that the pigment granules advance peripherally and in turn retreat toward the central area while the form of the chromatophore remains essentially unchanged.

Further evidence which indicates that the radial processes of the chromatophores are not extended and retracted with each corresponding change in the distribution of pigment is afforded by the fact that not infrequently as the pigment becomes concentrated in the central area of the chromatophore aggregates of pigment granules remain far out in the radial processes. If the radial processes were actually retracted, all the pigment granules would necessarily be carried toward the center with them. It might be suggested that these aggregates of pigment granules which remain at or near the periphery break through the surface film of the cytoplasm as the radial processes are withdrawn and are again engulfed as the latter are extended. However, this seems highly improbable.

The observations on the changes in the distribution of the pigment granules in chromatophores recorded in the preceding paragraphs substantiate similar observations made by Ballowitz on chromatophores in various species of teleosts. Ballowitz (1913) has, furthermore, described very delicate radial canaliculi in the chromatophores within which, he maintains, the pigment granules advance and retreat. The writer must confess he has not been able to observe such canaliculi in the chromatophores of *Paralichthys albiguttus* in either living or fixed material. Furthermore, the lack of any regular arrangement of the pigment granules in the xanthophores speaks strongly against the occurrence of radial canaliculi in these bodies.

INNERVATION OF CHROMATOPHORES.

Another important question regarding the functional activity of chromatophores involves their relationship to the nervous system. The results of operations on the eyes and nerves of fishes by Pouchet (1876), Šečerov (1909, 1913), Sumner (1911), and others indicate that the stimuli which normally call forth changes in shade or color which involve widespread changes in the distribution of the pigment granules in the chromatophores are received through the eyes. The experimental work of Mast (1914) proves conclusively that this conclusion is correct. The work of Pouchet (1876), furthermore, indicates that the chromatophores are under the direct control of the sympathetic nervous system. Ballowitz (1893) described a dense network of nerve fibers, presumably sympathetic in character, surrounding the chromatophores in the skin of certain fishes. The experimental work of Frisch (1910) on trout and minnows tends to show that the nerve fibers which control the chromatophores pass out at a precise level from the spinal cord into the sympathetic trunks and pass with them anteriorly and posteriorly. Frisch claims, furthermore, to have demonstrated a special center in the anterior end of the medulla whose stimulus brings on a contraction of the chromatophores.

In sections of the skin of *Paralichthys albiguttus* prepared by the pyridine-silver method the writer observed both medullated and nonmedullated nerve fibers which vary greatly in caliber. The medullated and the larger nonmedullated fibers were never observed in relationship with the chromatophores. However, many of the smaller nonmedullated fibers could be traced to their terminations on chromatophores (text fig. 5). These fibers do not form a dense network about chromatophores, as described and illustrated by Ballowitz (1893), but run more or less directly from the fiber bundles in the skin to their termination on the chromatic organs. The nonmedullated character of these fibers does not prove them to be sympathetic. However, this character, together with the small caliber of the fibers, strongly suggests that they are sympathetic in nature.

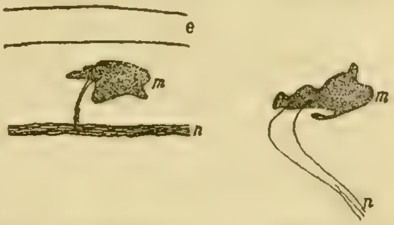

FIG. 5.—Camera lucida drawings of melanophores and nerve fibers associated with them in a section of the skin of *Paralichthys albiguttus* prepared by the pyridine-silver method. (*e*, epidermis; *m*, melanophores; *n*, nerve fibers.)

DETAILED STUDY OF CHROMATOPHORES AND GUANOPHORES IN SKIN OF FISH ON GIVEN BACKGROUNDS.

INTRODUCTION.

The experimental work of Mast proves conclusively that in members of the genus *Paralichthys* the skin simulates the background in color as well as in shade and pattern. In his summary he says:

> The range of changes in the skin in members of this genus is most remarkable. On a white background they become almost pure white, on a black background nearly black, and on gray backgrounds of various shades they become gray of very nearly the same shade. On blue, green, yellow, orange, pink, or brown of various hues they assume a color remarkably similar to that of the background. Reds of various tints and shades, however, are not very accurately simulated, but the color produced in the skin by each tint or shade of red is different from that produced by any other color and very different from that produced by gray regardless of the intensity.[a]

In the present investigation specimens of *Paralichthys albiguttus* were kept on backgrounds of given shades and colors until their skin simulated the shade or color of the background as nearly as possible. In general the shades and colors used were the same or similar to those used by Mast. The color-producing elements in the skin of these specimens, as well as of specimens newly taken, were studied microscopically in order to determine as accurately as possible what factors are involved in the production of given shades and colors.

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[a] Bulletin Bureau of Fisheries, vol. XXXIV, 1914, p. 225.

FISH NEWLY TAKEN.

The specimens used in this study were taken on sandy beaches near the laboratory. The majority of them were brownish gray in color, mottled with areas of darker and lighter shades. Occasionally a specimen was taken which showed only a very slight or no brownish tone.

In the layer immediately beneath the epidermis in these specimens the melanophores in the darker areas were nearly or quite maximally expanded, while those in the lighter areas were expanded to a lesser degree. In the lightest areas many of the melanophores were contracted to such an extent that nearly all of the pigment was concentrated in the central area. The melanophores lay immediately beneath the epidermis and were not obscured by other structural elements.

In the majority of the specimens examined most of the xanthophores in the layer immediately beneath the epidermis were contracted to such an extent that the major part of the pigment was concentrated in the central area. From this central pigmented area irregular aggregates of pigment granules extended peripherally into the proximal portions of one or more radial processes. In this condition the pigmented area is so irregular in form that the radial arrangement of the parts of the chromatophore is not apparent. In those specimens which showed a marked brownish tone the xanthophores just beneath the epidermis were expanded to a moderate degree, while in those which showed little or no brownish tone they were almost maximally contracted. The xanthophores lay appreciably deeper than the melanophores, and many of them were partly covered by the latter. Many of them also were partly or completely overlain by guanophores.

The guanophores in the layer immediately beneath the epidermis occurred either isolated or in small groups, usually without any apparent arrangement which could be correlated with the arrangement of chromatophores or their component parts. However, in some instances guanophores were arranged in a radial manner about chromatophores with which they were intimately associated. Guanophores were present in sufficient numbers to occupy the greater part of the surface area beneath the melanophores as well as between them. They were apparently less abundant and somewhat more opaque in the darker than in the lighter areas.

Among the chromatophores lying superficial to the proximal areas of the scales and, consequently, beneath the overlapping areas of other scales the melanophores were well expanded while the xanthophores were expanded to an appreciably greater degree than the xanthophores in the layer just beneath the epidermis. Relatively few guanophores occurred superficial to the proximal areas of the scales. These also appeared less opaque than those in the layer just beneath the epidermis. The chromatophores in the deeper layers of the skin are well expanded.

Obviously the darker shades in the color pattern of a fish newly taken are due primarily to the degree of expansion of the melanophores in the darker areas. The lighter shades are due not only to the degree of contraction of the melanophores in the lighter areas but also to the effect of the guanophores, which to a large extent obscure the melanin pigment in these areas. In specimens which show a marked brownish tone this tone depends primarily upon the degree of expansion of the xanthophores. However, the quality of the color is not that of the xanthine pigment. It is probably the result of a blending of the colors of xanthine and melanin pigment plus the optical effect of the guanophores and other structural elements. In specimens which show only a very slight or no brownish tone the xanthophores are strongly contracted and so thoroughly obscured by the guanophores that the xanthine pigment has little or no effect.

FISH ON BLACK BACKGROUND.

The specimens used in this study were kept in a wooden aquarium, the bottom and sides of which were painted black. Some of them remained in this aquarium for 21 days or longer, others for shorter intervals. In those in which simulation of the background was most nearly perfect the skin was very dark gray with a very slight brownish tone, and the whole surface of the body was more uniform in shade than it was in the specimens newly taken.

In the layer just beneath the epidermis in these specimens the majority of the melanophores in the darker areas were maximally expanded. These melanophores showed a relatively large unpigmented area at the center, and pigment was present in the radial processes well toward their peripheral extremities. In the lighter areas the melanophores were expanded to a somewhat lesser degree. Many of them showed a relatively small unpigmented area at the center, while others showed no unpigmented central area but were still well expanded. In many areas the radial processes of adjacent melanophores interdigitated with each other. Where this condition obtained, a relatively large portion of the surface area was occupied by melanin pigment. Furthermore, the melanophores lay immediately beneath the epidermis and were not obscured by other elements.

The majority of the xanthophores in the layer just beneath the epidermis were strongly contracted. The portion of the surface area occupied by xanthine pigment was relatively small in proportion to that occupied by melanin pigment. Furthermore, the xanthophores lay appreciably deeper than the melanophores and many of them were wholly or in part overlain by guanophores. Occasionally a specimen which had become adapted to a black background was observed which showed scarcely a trace of brownish color. In these specimens the xanthophores in the superficial layer of the skin were contracted to a somewhat greater degree than usual and were more effectively obscured by overlying guanophores.

Guanophores were present in the superficial layers of the skin in approximately the same abundance as in specimens newly taken. In some instances they lay beneath melanophores. However, the majority of them lay in the areas not occupied by melanophores.

The chromatophores lying superficial to the proximal areas of the scales and in the deeper layers of the skin showed approximately the same degree of expansion as the corresponding chromatophores in the skin of the darker specimens newly taken.

The essential difference in the color-producing elements in the skin of specimens adapted to a black background and specimens newly taken from their natural environment consists in a markedly greater degree of expansion of the melanophores and a somewhat greater degree of contraction of the xanthophores in the layer just beneath the epidermis in the former than in the latter. The chromatic organs in the deeper layers of the skin show approximately identical conditions in both cases. The time required for a specimen taken from its natural environment to become maximally black is relatively short. Microscopic examination of the color-producing elements in the skin of specimens which had been on the black background two or three days showed conditions essentially identical with the conditions of the color-producing elements in the skin of specimens which had been kept on a black background continuously for a period of 21 days.

The accompanying figure (text fig. 6) is an attempt to illustrate the vertical distribution of chromatophores and guanophores in the layer just beneath the epidermis and in the layer just beneath this one overlying the proximal area of a scale in the skin of a specimen which was thoroughly adapted to a black background. The solid areas represent melanin pigment, the stippled areas include both xanthophores and guanophores. Figure 3, plate 1, represents a camera lucida drawing of chromatophores and guanophores in the layer just beneath the epidermis in the skin of a specimen 23 cm. in length which had been kept on a black background for a period of 21 days.

FISH ON WHITE BACKGROUND.

The specimens used in this study were kept for intervals varying from 5 to 25 days in a wooden aquarium the bottom and sides of which were painted white. Because of sediment in the water the bottom and sides of the aquarium assumed a brownish-yellow tinge. Consequently, the background to which these specimens became adapted was not pure white. When fully adapted to this background, the color of these specimens was grayish-white with a brownish-yellow tone, mottled with areas of a somewhat darker shade.

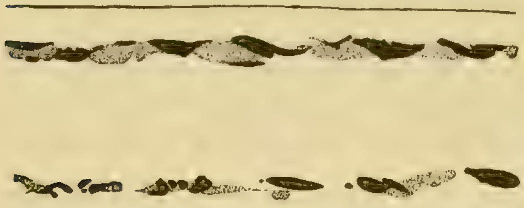

FIG. 6.—Camera lucida drawing illustrating the vertical distribution of chromatophores and guanophores just beneath the epidermis and superficial to the proximal area of a scale in the skin of a specimen of *Paralichthys albiguttus* adapted to a black background. Solid color represents melanin pigment, stippling includes both xanthophores and guanophores.

The melanophores in the layer just beneath the epidermis in the skin of these specimens were all contracted to a greater or lesser degree. In the lighter areas the majority of them were maximally contracted. In this condition the pigment was concentrated in the central area into a rounded mass, which usually lay somewhat deeper than the melanophores in their expanded condition. In areas of a somewhat darker shade the melanophores were contracted to a lesser degree. In these melanophores the major part of the pigment was concentrated in the central area, while masses of pigment granules extended for a short distance into the proximal portions of many of the radial processes or farther peripherally in a few radial processes. Melanophores occurred not infrequently, even in the lighter areas, in which the pigment was not appreciably concentrated. In these instances the central area of the melanophore lay at a deeper level than the peripheral portions and was deeply covered by guanophores. In the darkest areas many of the melanophores remained expanded to a moderate degree. In all these conditions the melanophores were obscured to a greater or lesser extent by associated guanophores.

The xanthopores in the layer just beneath the epidermis were contracted to a somewhat lesser degree than the corresponding xanthophores in the skin of specimens adapted to a black background, but were obscured to a greater extent by overlying guanophores. The majority of these xanthophores showed a heavily pigmented central area from which masses of pigment granules extended peripherally into the proximal portions of a few of the radial processes, giving the pigmented area a very irregular outline. In some instances the aggregates of pigment granules extended farther peripherally in one or two of the radial processes, while the others were entirely free from pigment. Relatively few xanthophores were expanded to a moderate degree and showed a more symmetrical distribution of the pigment granules. The ratio of the surface area occupied by xanthine pigment to that occupied by melanin pigment was appreciably greater in these specimens than in those adapted to a black background. However, the xanthophores were more effectively obscured by overlying guanophores in the former than in the latter.

Guanophores were apparently more numerous in the layer just beneath the epidermis in the skin of these specimens than in the skin of specimens newly taken. They occupied nearly all the surface area and were closely aggregated about many of the melanophores. As indicated in an earlier section of this paper, whether or not a real increase in the number of guanophores in the superficial layer of the skin occurs in specimens which become thoroughly adapted to a white background could not be definitely determined. Doubtless, the more complete occupation of the surface area by the guanophores in the skin of these specimens is due, at least in part, to the expansion of these bodies. Nevertheless, the changes which bring about the more complete occupation of the surface area by the guanophores constitute an important factor in the production of a still lighter shade following the initial response of the fish to a white background.

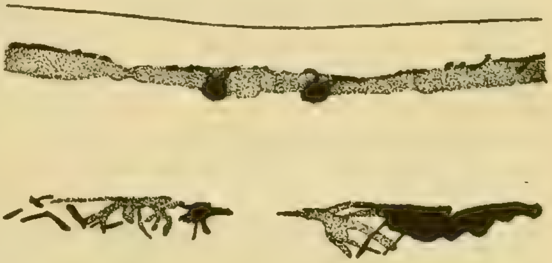

Fig. 7.—Camera lucida drawing illustrating the vertical distribution of chromatophores and guanophores just beneath the epidermis and superficial to the proximal area of a scale in the skin of a specimen of *Paralichthys albiguttus* adapted to a white background. Solid color represents melanin pigment, stippling includes both xanthophores and guanophores.

Both melanophores and xanthophores lying superficial to the proximal areas of the scales and in the deeper layers of the skin were contracted to a somewhat lesser degree, respectively, than those in the layer just beneath the epidermis. In many instances, while the radial processes could not be definitely outlined, the peripheral portions of many of them which contained no pigment granules still assumed a slight yellowish tinge.

The accompanying figure (text fig. 7) is an attempt to illustrate the vertical distribution of chromatophores and guanophores in the layer just beneath the epidermis and in the layer overlying the proximal area of a scale in the skin of a specimen which was thoroughly adapted to a white background. The solid areas represent melanin pigment, the stippled areas include both xanthophores and guanophores. Figure 4, plate 1, represents camera lucida drawings of chromatophores and guanophores in the layer just beneath the epidermis in a lighter and a darker area of the skin of a specimen 22 cm. in length which had been kept on a white background for a period of 25 days.

All the specimens which were kept in white aquaria became adapted to the white background very rapidly. The initial response to a white background consists in a marked concentration of the pigment granules in the majority of the melanophores and the depression of the central area of many of those in which the pigment does not become concentrated. This initial response may require but a few seconds and results in a distinctly whitish shade. However, a fish which has not previously been adapted to a white background does not become maximally white for a week or longer. Complete adaptation to a white background involves a rearrangement and probably an increase in the number of the guanophores and a material reduction in the number of melanophores in the layer just beneath the epidermis. On the other hand, a specimen which has recently been thoroughly adapted to a white background, but allowed to assume a darker shade for a short time, resumes a maximally white shade very promptly when again placed on a white background. The degree of concentration of the pigment granules in the chromatophores and the relationships of the guanophores with these bodies are essentially the same after the initial response in a specimen which has previously been thoroughly adapted to a white background as in one which has been on a white background continuously for a prolonged period.

The effect of a thorough adaptation to a white background remains apparent for a considerable length of time after the fish is placed on a dark background. This is shown by the following observations: A specimen 17 cm. in length which had been kept in a white aquarium for four weeks was placed, on August 2, in an aquarium painted black. This specimen assumed a somewhat darker shade almost immediately and gradually became darker. On August 4 it still remained somewhat lighter than the darker specimens newly taken. Many of the melanophores in the layer just beneath the epidermis were well expanded, but the central area still remained depressed and in many instances covered by guanophores. In some areas many of the melanophores remained almost maximally contracted while guanophores remained closely aggregated about them. In general, the melanophores were obscured to a lesser degree than when the fish was transferred from the white aquarium. On August 7 it had become very much darker, but not maximally black. In many areas the melanophores were maximally expanded, and their central areas were no longer depressed. In other areas they were expanded only to a moderate degree, while many of them still remained somewhat obscured by guanophores. The xanthophores remained in approximately the same condition as they were when the fish was transferred from the white aquarium. Guanophores still remained apparently more numerous in the superficial layer of the skin than in specimens which had not been adapted to a light background, but were somewhat contracted. Consequently, they occupied less of the surface area than when the fish still assumed a lighter shade. On August 12 this specimen appeared nearly as dark as other specimens in the same aquarium which were thoroughly adapted to the black background. The melanophores in the superficial layer of the skin now showed approximately the same degree of expansion as the corresponding melanophores in the skin of a specimen which was maximally black. Neither were they any longer obscured by overlying guanophores. These observations, in so far as they refer to the rate of adaptation, are in harmony with those presented by Mast.[a]

FISH ON YELLOW BACKGROUND.

The specimens used in this study were kept on a gamboge-yellow background for intervals varying from 5 to 26 days. When thoroughly adapted to this background, they were grayish yellow in color, mottled with areas of darker and lighter shades.

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[a] Bureau of Fisheries, document no. 821, p. 195-199.

In these specimens the majority of the melanophores in the layer just beneath the epidermis were contracted only to a moderate degree. In the lighter areas the melanophores were contracted to a greater degree, but rarely was the pigment all concentrated in the central area. The melanophores lay immediately beneath the epidermis and were not obscured to an appreciable extent by overlying guanophores. However, the central area of those most fully expanded was not infrequently somewhat depressed.

Many of the xanthophores in the layer just beneath the epidermis were apparently maximally expanded, while others were expanded only to a moderate degree. In those which were not fully expanded the major portion of the pigment was concentrated in the central area, while masses of pigment granules extended toward the periphery but a short distance in some of the radial processes and farther in others. The pigmented area in these chromatophores was usually very irregular in outline. Rarely was a xanthophore observed in which all the pigment was concentrated in the central area. The ratio of the surface area occupied by xanthine granules to that occupied by melanin granules was relatively large. Because of the wider distribution of the pigment granules the color of individual xanthophores was less intense than in the skin of specimens not adapted to a yellow background.

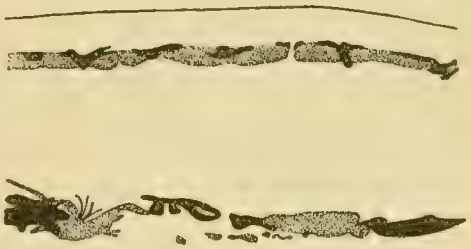

Fig. 8.—Camera lucida drawing illustrating the vertical distribution of chromatophores and guanophores just beneath the epidermis and superficial to the proximal area of a scale in the skin of a specimem of *Paralichthys albiguttus* adapted to a yellow background. Solid color represents melanin pigment, stippling includes both xanthophores and guanophores.

The guanophores in the layer just beneath the epidermis occupied a relatively large part of the surface area, rarely overlying melanophores, but very commonly overlying xanthophores, at least in part. However, the xanthine pigment was not largely obscured by them. Guanophores which lay above or in immediate contact with xanthophores assumed a greenish-yellow tinge. This phenomenon was more apparent in specimens adapted to a yellow background than in others, because the xanthine pigment in the former was more widely distributed. Guanophores not in close proximity with xanthine or melanin pigment in the skin of specimens adapted to a yellow background did not differ in shade or color from corresponding guanophores in the skin of specimens newly taken or those adapted to a dark background. The yellow color of the background had no direct effect upon the color of these bodies.

Both melanophores and xanthophores lying superficial to the proximal areas of the scales and in the deeper layers of the skin were well expanded, the xanthophores to a somewhat greater degree than the melanophores. Relatively few guanophores occur in these layers.

The accompanying figure (text fig. 8) is an attempt to illustrate as nearly as possible the vertical distribution of chromatophores and guanophores in the layer just beneath the epidermis and in the layer overlying the proximal area of the scales in the skin of a specimen which was thoroughly adapted to a yellow background. The solid areas represent melanin pigment, the stippled areas include both xanthophores and guanophores. Figure 5, plate 1, represents a camera lucida drawing of chromatophores and guanophores in the layer just beneath the epidermis in the skin of a specimen, 17 cm. in length, which had been kept on a yellow background for a period of 26 days.

All the specimens placed in a yellow aquarium became adapted to the yellow background almost as rapidly as those which were placed in a white aquarium did to the white background. The initial response of a dark-colored fish to a yellow background consists in a moderate degree of contraction of the melanophores and a marked degree of expansion of the xanthophores in the superficial layers of the skin. This initial response of a specimen which has not previously been adapted to a yellow background occurs somewhat less promptly than the initial response of a specimen newly taken to a white background. It results in a distinctly grayish-yellow color of a light shade. The production of a maximally yellow color requires no longer time than the production of a maximally white color. The complete adaptation to a yellow background involves some rearrangement of the guanophores and a moderate reduction in the number of melanophores in the layer just beneath the epidermis. The reduction in the number of melanophores is less marked than in the skin of specimens adapted to a white background. The averages of actual counts of the number of melanophores in a given unit area on detached scales taken from various parts of the body of specimens newly taken and of specimens thoroughly adapted to a yellow background, indicate a reduction in the number of melanophores in the layer just beneath the epidermis in the latter of approximately 16 per cent. No change in the number of xanthophores could be determined.

FISH ON GREEN BACKGROUND.

The specimens used in this study were kept, for intervals varying from 5 to 28 days, in a wooden aquarium the bottom and sides of which were painted moderately dark green. When thoroughly adapted to this background the general color of these specimens was a little lighter and more uniform than the color of the majority of the specimens newly taken and showed a distinct yellowish-green tone.

Many of the melanophores in the layer just beneath the epidermis in the skin of these specimens were nearly or quite maximally expanded while others were expanded only to a moderate degree. The condition of the melanophores in this layer did not differ materially from the condition of the corresponding bodies in the skin of many of the specimens newly taken in which the general color was most uniform.

The xanthophores in the layer just beneath the epidermis were expanded to a moderate degree. Many of them were in part overlain by guanophores, but were not largely obscured by the latter. The percentage of the total surface area occupied by xanthine pigment is appreciably greater in these specimens than in those adapted to either a black or a white background, but materially less than in those adapted to a yellow background.

The guanophores in the superficial layer of the skin occupied, approximately, the same percentage of the surface area as they did in the majority of the specimens newly taken. Guanophores which lay above or in immediate proximity with xanthine pigment assumed a greenish-yellow tinge. However, this was no more apparent in these specimens than in those adapted to a yellow background. The green background had no direct effect on either the shade or the color of the guanophores.

Superficial to the proximal areas of the scales and in the deeper layers of the skin both melanophores and xanthophores showed, approximately, the same degree of expansion as the corresponding chromatophores in the skin of specimens adapted to a moderately dark-gray background. Relatively few guanophores occurred in these layers.

Figure 6, plate II, is a camera lucida drawing of chromatophores and guanophores in the layer just beneath the epidermis in the skin of a specimen 19 cm. in length which had been kept on a green background continuously for a period of 28 days. The vertical distribution of chromatophores and guanophores in the skin of specimens adapted to a green background does not differ essentially from the vertical distribution of these elements in the skin of any moderately dark-colored specimen.

As a fish becomes adapted to a green background the melanophores in the superficial layer of the skin become expanded to approximately the same degree as in one adapted to a moderately dark-gray background. The xanthophores become expanded to a somewhat greater degree than the corresponding bodies in the skin of a specimen adapted to a gray background. That the guanophores in the superficial layer may assume somewhat different spacial relationships with the chromatophores is quite probable. However, no conclusive evidence on this point could be obtained. Greenish tones can not be observed microscopically except in the guanophores which lie in close proximity with xanthine pigment and in the almost pigment-free peripheral portions of the radial processes of some of the xanthophores. However, these greenish tones may be observed quite as well in the skin of specimens which have not been on a green background.

A microscopic study of the color-producing elements in the skin of these specimens affords no very definite data upon which to base an explanation of the cause of the greenish color which they assume. The most definite finding is the ratio of the surface area occupied by xanthine pigment to that occupied by melanin pigment. Doubtless, the greenish color is due to a mingling of the colors of xanthine and melanin pigment plus the optical effects due to the diffraction of light by the guanin crystals in the guanophores. The dark shade is due primarily to the degree of expansion of the melanophores.

FISH ON RED BACKGROUND.

Some of the specimens used in this study were kept for an interval of 21 days, others for a shorter interval, in a wooden aquarium, the bottom and sides of which were painted dark-carmine red. When thoroughly adapted to this background these specimens were reddish brown in color and of a shade approximately as dark as that of specimens adapted to a moderately dark-gray background.

The melanophores in the layer just beneath the epidermis in the skin of these specimens were all well expanded. In the darker areas the majority of them were nearly or quite maximally expanded; in the lighter areas they were expanded only to a moderate degree. In general, the melanophores in the superficial layer of the skin were expanded to a somewhat greater degree than in the majority of the specimens newly taken.

Among the xanthophores in the layer just beneath the epidermis, those which contain orange-colored pigment were well expanded, while those which contain yellow pigment were strongly contracted. In many areas the orange-colored xanthophores were nearly or quite maximally expanded; in others they were expanded only to a moderate degree. The majority of the yellow xanthophores were contracted to such a degree that the major part of the pigment was concentrated in the central area. Not infrequently xanthophores of this type were observed in which all the pigment was concentrated in the central area. Many of the xanthophores which were most strongly contracted were largely obscured by associated guanophores. Those which were expanded to a greater or lesser degree were not largely obscured by other elements except where they were in part overlain by melanophores. The ratio of the surface area occupied by xanthine pigment to that occupied by melanin pigment was greater than in specimens adapted to other dark-colored backgrounds, but appreciably less than in those adapted to a yellow background.

In general, the guanophores in the superficial layer were more intimately associated with the xanthophores than with the melanophores, and appeared to be arranged with respect to the former rather than the latter; consequently, they occupied a relatively large part of the surface area not occupied by melanophores. Inasmuch as a relatively large percentage of the guanophores lay in proximity with xanthophores, the greenish-yellow tone of the former, due to their proximity with xanthine pigment, was widespread and very apparent. The red background had no direct effect either on the shade or the color of the guanophores.

Superficial to the proximal areas of the scales and in the deeper layers of the skin the melanophores and orange-colored xanthophores were well expanded, while the yellow xanthophores were expanded only to a moderate degree. The peripheral pigment-free portions of many of the xanthophores, as well as the guanophores lying in proximity with xanthine pigment, assumed the same greenish-yellow tone as the guanophores lying in proximity with xanthine pigment in the superficial layer.

Figure 7, plate II, is a camera lucida drawing of chromatophores and guanophores as they appeared in the layer just beneath the epidermis in the skin of a specimen 20 cm. in length, which had been kept on a dark-red background for a period of 21 days. The vertical distribution of chromatophores and guanophores in the skin of specimens adapted to a dark-red background does not differ essentially from the vertical distribution of these elements in the skin of any dark-colored specimen.

Adaptation to a dark-red background involves a response on the part of the melanophores similar to the response of these organs to a moderately dark-gray background. The xanthophores whose color approximates the color of the background most closely, i. e., those containing orange-colored pigment, become greatly expanded. Consequently, the pigment which simulates the color of the background most closely becomes almost maximally effective. Furthermore, a relatively large percentage of the guanophores lie in proximity with xanthophores. Doubtless, the resulting reddish-brown color is due to a mingling of the colors of the xanthine and the melanin pigments plus the optical effects due primarily to those guanophores which lie in proximity with xanthophores. The dark shade is due to the degree of expansion of the melanophores.

Specimens newly taken which were placed in a red aquarium responded very promptly to the red background. The initial response involves a marked degree of expansion of the melanophores and orange-colored xanthophores and a moderate degree of contraction of the yellow xanthophores in the superficial layers of the skin.

It results in a color which approximates very closely the color of specimens which are thoroughly adapted to the same background. None of the specimens used in this study ever showed any color which approximated the red color of the background more closely than does the orange pigment.

FISH ON BLUE BACKGROUND.

The specimens used in this study were kept, for intervals varying from 5 to 22 days, in a wooden aquarium the bottom and sides of which were painted dark indigo-blue. Adaptation to this background was, perhaps, less perfect than it would have been to a blue background of a lighter shade. Those specimens which simulated the color of the background most closely were dark gray with a greenish-blue tone.

In these specimens many of the melanophores in the layer just beneath the epidermis were nearly or quite maximally expanded; others were expanded to a somewhat lesser degree. In general, the melanophores in this layer were expanded to a slightly lesser degree than in the skin of specimens adapted to a black background.

The xanthophores in the layer just beneath the epidermis were strongly contracted. In many areas the majority of them were contracted to a maximum degree. In others they were almost maximally contracted. In general the xanthophores lay somewhat deeper than when they are contracted to a lesser degree and were largely obscured by overlying guanophores.

The guanophores in the superficial layer were more definitely arranged with reference to the melanophores and were apparently more intimately associated with these bodies than in any of the conditions described above. Not infrequently guanophores were closely aggregated around melanophores and extended well beneath the peripheral portions of the latter. Because so many of the guanophores were associated with melanophores in this manner there were relatively large areas between the melanophores not occupied by guanophores. Wherever guanophores were in close proximity with xanthine pigment they assumed a greenish-yellow tinge. However, relatively few guanophores were affected in this manner by reason of the relatively great degree of contraction of the xanthophores. On the other hand, many of the guanophores closely associated with melanophores and not in close proximity with xanthine pigment showed a greenish-blue metallic tone. The blue background had no apparent direct effect on the shade or the color of the guanophores.

Superficial to the proximal areas of the scales and in the deeper layers of the skin the melanophores were nearly or quite maximally expanded, while the xanthophores were strongly contracted. Many of the guanophores which were closely associated with melanophores showed the same greenish-blue metallic tone as was apparent in the superficial layer of the skin.

Figure 8, plate II, is a camera lucida drawing of chromatophores and guanophores as they appeared in the layer just beneath the epidermis in the skin of a specimen, 20 cm. in length, which had been kept on a dark-blue background for a period of 22 days. The vertical distribution of chromatophores and guanophores in the skin of specimens adapted to a dark-blue background does not differ essentially from the vertical distribution of these elements in the skin of any dark-colored specimen.

Adaptation to a dark-blue background involves almost maximum expansion of the melanophores and almost maximum contraction of the xanthophores in the superficial layers of the skin. The guanophores also undergo some changes in their relationships with the chromatophores, by which many of them become more intimately associated with melanophores, leaving relatively few intimately associated with xanthophores. Relatively few guanophores show a greenish-yellow tinge due to their proximity with xanthine pigment. On the other hand, many guanophores show a greenish-blue metallic tone, probably due to their intimate association and particular spacial relationships with well-expanded melanophores. Obviously the dark shade assumed by specimens adapted to a dark-blue background is due to the degree of expansion of the melanophores. The greenish-blue tone is probably due largely to the optical effect produced by the guanophores which are most intimately associated with melanophores.

DISCUSSION.

A comparative study of living material and preparations of the skin of specimens of *Paralichthys albiguttus* adapted to backgrounds of the various shades and colors used in this investigation indicates that shade depends primarily upon the degree of distribution of the melanin pigment in the melanophores and the spacial relationships of the guanophores with these bodies in the superficial layers of the skin. The xanthophores probably play no important part in the determination of shade. The melanophores in the deeper layers of the skin always respond less promptly and to a lesser degree to changes in the shade of the background than those in the superficial layer.

The most obvious response to a change in the color of the background is a change in the distribution of the xanthine granules in the xanthophores. Shades of yellow and orange probably depend primarily upon the relative degree of expansion of the xanthophores containing yellow and orange pigments. In general the particular quality of the color assumed depends on a complex group of factors which do not lend themselves readily to a detailed analysis. Some of the colors assumed may be duplicated by mixing pigments of the colors represented in the pigments contained in the chromatophores. Doubtless, these colors depend largely on the relative degree of expansion of the melanophores and xanthophores. Colors which can not be duplicated in this manner, doubtless, depend on the relative degree of expansion of the melanophores and xanthophores plus the optical effects due to the diffraction of light by the guanin crystals in the guanophores and possibly the absorption and diffraction of light by other structural elements in the skin. The optical effects produced by the guanin crystals are probably modified to some extent by the particular spacial relationships of the guanophores with the chromatic organs.

Obviously, certain colors are simulated much more perfectly than others. Among the colors used in this investigation yellow and green were simulated much more perfectly than dark red and dark blue. Autochrome plates published by Mast (1914) show that some of his specimens simulated the color of blue backgrounds much more perfectly than the specimens used in the present investigation. However, his specimens which were adapted to a red background did not simulate the color of the background any more closely than those adapted to a red background in this investigation. As indicated in an earlier section of this paper, none of the specimens placed on a dark-red background showed any color which approximated red more closely than the orange-colored pigment in the xanthophores. In view of these facts, the conclusion that all colors can be reproduced in the skin of the flounder is unwarranted.

SUMMARY.

1. Chromatophores in the skin of *Paralichthys albiguttus* are of two types, viz, melanophores and xanthophores. The former contain melanin granules which are dark brown or black, the latter contain xanthine granules which vary in color from yellow to orange. Changes in shade or color are due primarily to changes in the distribution of the pigment in the chromatophores and changes in the relationships of the guanophores with these bodies.

2. Many melanophores are eliminated from the skin through the epidermis. Under certain conditions the number of melanophores in the layer just beneath the epidermis becomes materially reduced.

3. Evidence is advanced in support of the theory that changes in the distribution of the pigment in the chromatophores are brought about by movements of the pigment granules toward the periphery and in turn back toward the central area while the form of the chromatophores remains essentially unchanged.

4. The evidence available indicates that the chromatophores are under the direct control of the sympathetic nervous system.

5. Shade is due primarily to the degree of expansion of the melanophores in the superficial layers of the skin. Very light shades maintained for a prolonged period involve a reduction in the number of melanophores in the superficial layer.

6. The initial response to a yellow background involves a moderate degree of contraction of the melanophores and a marked degree of expansion of the xanthophores in the superficial layers of the skin. Thorough adaptation to a yellow background involves a moderate reduction in the number of melanophores in these layers.

7. Adaptation to a green background involves approximately the same degree of expansion of the melanophores and a somewhat greater degree of expansion of the xanthophores in the superficial layers of the skin than adaptation to a moderately dark-gray background. The resultant yellowish-green tone probably depends upon the ratio of the distribution of the xanthine to the distribution of the melanin pigment plus the optical effect due to the diffraction of light by the guanin crystals in the guanophores.

8. Adaptation to a dark-red background involves almost maximum expansion of the melanophores and the xanthophores containing orange-colored pigment and a marked degree of contraction of the xanthophores containing yellow pigment in the superficial layers of the skin. The resulting reddish-brown color is due largely to the wide distribution of orange pigment, the effect of which is probably modified to some extent by the blending of orange and black and the optical effects produced by the guanophores. The dark shade is due to the wide distribution of melanin pigment.

9. Adaptation to a dark-blue background involves almost maximum expansion of the melanophores and almost maximum contraction of the xanthophores in the superficial layers of the skin. Many of the guanophores also become arranged with reference to the melanophores and closely associated with them. The xanthine pigment probably has little effect in the resultant color. The dark shade is due primarily to the wide distribution of the melanin pigment. Doubtless, the greenish-blue tone depends largely upon the optical effects produced by those guanophores which are closely associated with melanophores.

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EXPLANATION OF PLATES.

PLATE I.

FIG. 1.—Expanded melanophore highly magnified.

FIG. 2.—Expanded xanthophore highly magnified.

FIG. 3.—Camera lucida drawing of chromatophores and guanophores just beneath the epidermis in a specimen of *Paralichthys albiguttus* adapted to a black background. × 550. The grayish tones represent guanophores.

FIG. 4.—Camera lucida drawing of chromatophores and guanophores just beneath the epidermis in two areas of the skin of a specimen of *Paralichthys albiguttus* adapted to a white background. × 550.

FIG. 5.—Camera lucida drawing of chromatophores and guanophores just beneath the epidermis in a specimen of *Paralichthys albiguttus* adapted to a yellow background. × 550.

PLATE II.

FIG. 6.—Camera lucida drawing of chromatophores and guanophores just beneath the epidermis in a specimen of *Paralichthys albiguttus* adapted to a green background. × 550.

FIG. 7.—Camera lucida drawing of chromatophores and guanophores just beneath the epidermis in a specimen of *Paralichthys albiguttus* adapted to a dark-carmine red background. × 330.

FIG. 8.—Camera lucida drawing of chromatophores and guanophores just beneath the epidermis in a specimen of *Paralichthys albiguttus* adapted to a dark-indigo blue background. × 550.

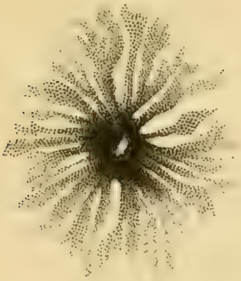


FIG. 1

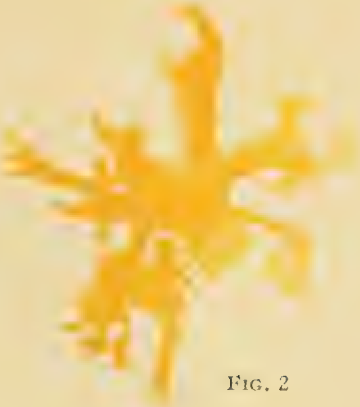


FIG. 2

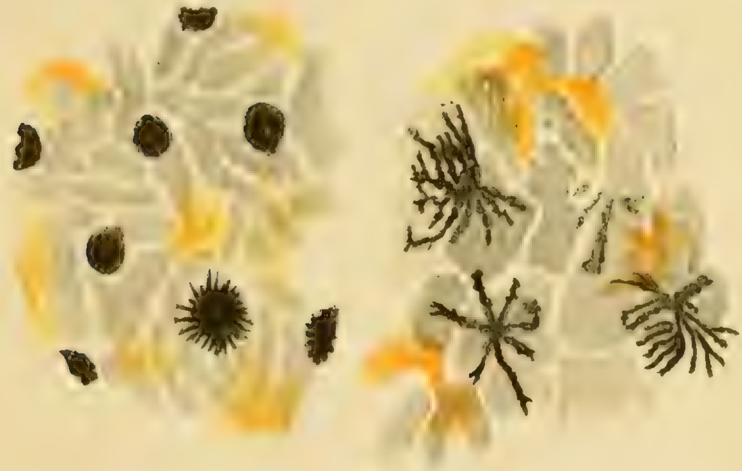


FIG. 4

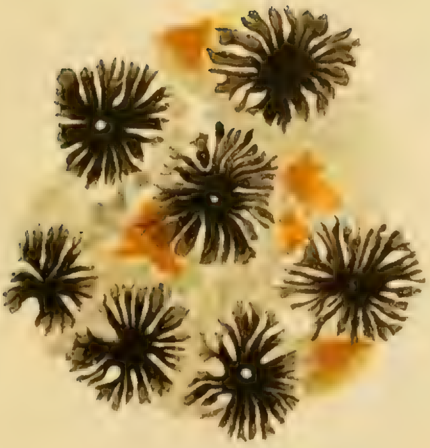


FIG. 3

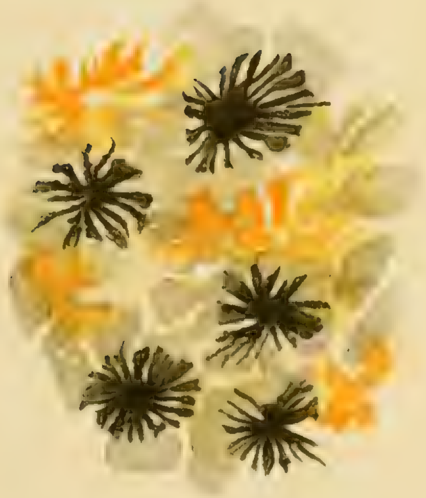


FIG. 5

A HOEN & CO BALTIMORE

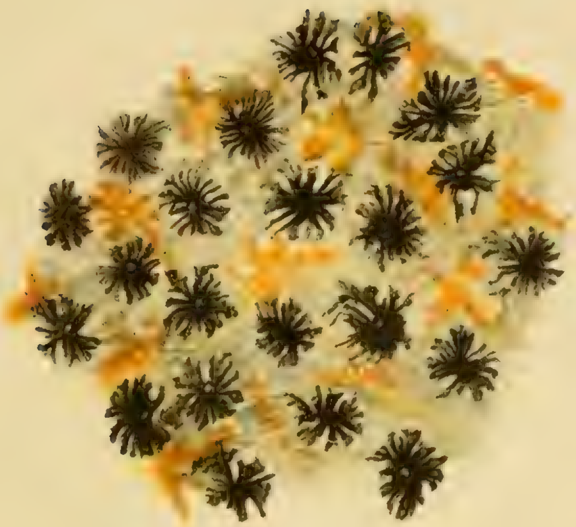


FIG. 7

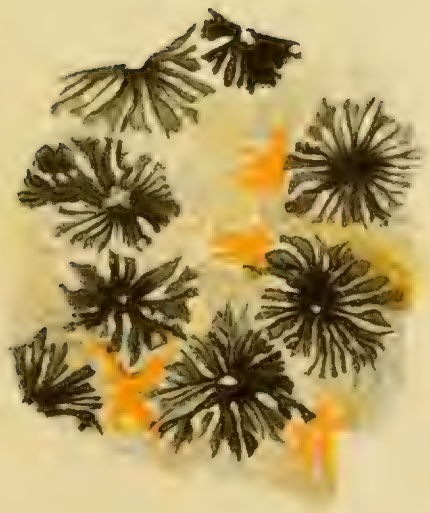


FIG. 8

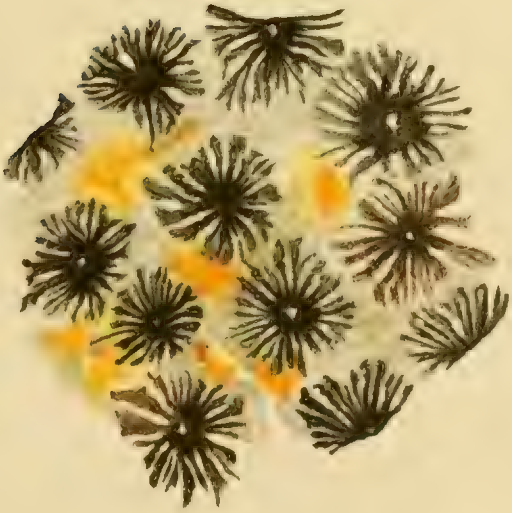


FIG. 6

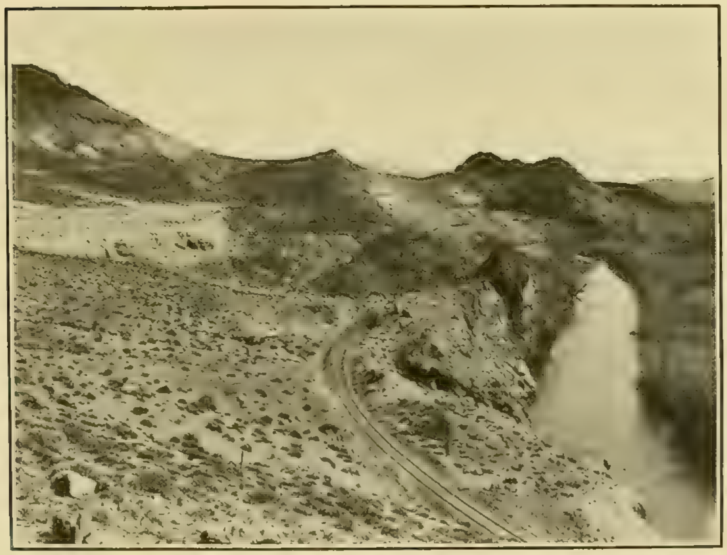
A HOEN & CO BALTIMORE

THE FISHES OF THE LAHONTAN SYSTEM OF NEVADA AND NORTHEASTERN CALIFORNIA

⁂

By John Otterbein Snyder
Stanford University, California

(*a*) Truckee River near its source.



(*b*) Truckee River in the desert near Derby. Lahontan sediments are seen on the left.

(*a*) Winnemucca Slough near mouth, June, 1911. Quaternary shore lines in the distance.

(*b*) Tufa castle, Pyramid Lake, showing water level in June, 1911.

THE FISHES OF THE LAHONTAN SYSTEM OF NEVADA AND NORTHEASTERN CALIFORNIA.

⁂

By JOHN OTTERBEIN SNYDER.

INTRODUCTION.

The fishes of the Great Basin of North America are of unusual interest, as they occupy basins which are without exterior drainage, and are consequently in much the same position as animals on oceanic islands; and, furthermore, this isolation eliminates from the question of distribution one possible means of dispersal, namely, the open ocean. The islandlike systems which these fishes occupy are completely surrounded by greater and more extensive river systems which have oceanic drainage. To the island systems these bear a continental relation. The situation attracts further attention when it is recalled that each of the greater systems contains a distinct and characteristic fish fauna of which many genera are not found elsewhere.

The various drainage areas of the Great Basin are separable into three distinct groups: First, those included within the State of Utah and which were at one time tributary to the ancient Lake Bonneville; second, those of northern Nevada and northeastern California, which formed a part of the Quarternary Lake Lahontan; and, third, a number of detached basins in southeastern Oregon that were once more extensive than now. These latter were lately examined by agents of the Bureau of Fisheries, and their species are fairly well known.[a]

The present paper deals with the fishes of the second group, the Lahontan system. It includes a systematic account of the species, a discussion of their economic importance, and their distribution and relationships. Some attention is also given to the possible bearing of distribution and relationships on the geological history of the region.[b]

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[a] Bulletin, Bureau Fisheries, vol. XXVII, 1907, p. 69.

[b] Specimens were collected and field observations made by the writer while serving as a temporary assistant of the United States Bureau of Fisheries. Mr. C. H. Richardson, a student of Stanford University, aided during the summer of 1911, and a recent report by him (Proceedings U. S. National Museum, vol. 48, p. 403) embodies an account of the reptiles which were seen. Officers of the State Fish Commissions of both Nevada and California have shown an interest in the work, and acknowledgments for direct assistance are specially due to Hon. George T. Mills, Messrs. Ernest Schaeffle, E. W. Hunt, George E. West, and Frank P. Cady. Prof. S. B. Doten, of the University of Nevada, an enthusiastic angler, and Dr. Maxwell Adams, of the same institution, have furnished valuable information regarding the fishes and the region in general. Work in the vicinity of Pyramid Lake was made possible through the courtesy of Mr. Joseph D. Oliver, superintendent of the Indian agency. A collection of fishes made by Dr. C. H. Gilbert in the headwaters of Carson and Walker Rivers has been consulted, and all the material from the system, including the type specimens, which are preserved in the National Museum, were examined. Types and paratypes of the species here described and a large representative collection have been deposited in the National Museum. A collection was also retained at Stanford University. The drawings are by Mr. W. S. Atkinson.

RIVERS AND LAKES OF THE LAHONTAN SYSTEM.

The Lahontan system drains a huge basin embracing about 40,700 square miles of arid and semiarid tableland which is roughly broken by barren and rugged mountain ranges. It includes on the west the abrupt and often precipitous forest-covered wall of the Sierras, with its towering masses of snow-covered peaks, and it stretches away to the east, north, and south in an apparently endless extent of forbidding desert. The system includes six isolated basins, viz, the Truckee River, Honey Lake, Eagle Lake, Quinn River, Walker River, and the Carson-Humboldt. Here are found rivers of considerable size, many perennial creeks, and smaller streams of more or less intermittent flow, besides several large, deep, and very beautiful lakes. (See map, p. 86.)

Truckee River is the largest and most important stream of the system. It originates as the outlet of Lake Tahoe, descends 2,460 feet in about 100 miles to Pyramid and Winnemucca Lakes, where its water is carried off by evaporation. Rising in a forested region (pl. III, *a*), it passes down a wooded canyon and emerges on the desert, where its banks are alternately bordered by irrigated fields, sage-covered sands, and barren rocks (pl. III, *b*). Its lower course is inclosed for a considerable distance between walls of eroded Quaternary sediments, beyond which the gorge broadens into a green-carpeted forest of large cottonwoods. Just before entering Pyramid Lake the river bifurcates, a lateral channel, known as Winnemucca Slough, abruptly turning to the right and conveying a considerable part of the water into Winnemucca Lake. The surface of the latter is lower than Pyramid Lake, and at times after unusually high water a back flow sets in from Pyramid Lake through the slough. The water of both lakes is remarkably limpid except near the inlets. It is brackish to a degree which prevents the growth of arborescent vegetation along the shores, yet the submerged rocks are covered with algæ and the water swarms with fishes. The monotony of the arid shores occasionally is broken by towering, castellated tufa crags, which suggest ancient ruins, and the valleys are bordered by high rugged mountains, against whose sides are plainly traced the levels of a greater lake (pl. IV, *a*), often in overhanging tufa masses of fantastic form. Pyramid Lake contains several small islands, on two of which are large breeding colonies of water birds.

Honey Lake is a very shallow body of water, which receives Long Valley and Susan Creeks. The latter is a trout stream of considerable size.

Eagle Lake is large, deep, and irregular in outline. Apparently it was once a tributary to Lake Lahontan, but is now separated from Honey Lake Basin by a wall of permeable rock, from the base of which many springs unite to form a branch of Susan Creek. The water of Eagle Lake is clear and cold. The western and southern shores are largely forested. The surface level is subject to periodical fluctuations, recently rising so high as to submerge a considerable area and kill many large conifers. Pine Creek is the only tributary.

Carson and Humboldt Rivers flow from opposite directions into Carson, South Carson, and Humboldt Lakes. These are shallow evaporation basins, irregular and inconstant in outline, their waters laden with silt and charged with mineral salts.

Quinn River debouches on the almost level floor of Black Rock Desert. For a large part of its course it is sluggish and muddy, winding here and there through extensive marshes.

Walker Lake is a rival of Pyramid Lake in scenic beauty, lying in a long narrow valley with towering mountains on either side and the desert sloping down to the water's edge. It is comparatively fresh near the inlet, but grows more saline toward the lower end, where no fishes except carp are said to go. Walker River is its only tributary.

In addition to the larger basins here described there are several creeks which are isolated. One or two of these north of Black Rock Desert are said to contain fishes.

The streams of the entire system are much alike in that they have their origins in the mountains and are often fed by melting snow. Their upper courses are cool, clear, and pure; but on reaching the valleys the currents slacken, the water at length becoming warmer and often silted and alkaline. They are all subject to great changes in volume,[a] gradually or even suddenly becoming raging torrents and again decreasing in size until in some cases their currents fail and their waters are dissipated through evaporation or lost in the thirsty sands. Of late years much water has been used in irrigation, the entire flow of some streams being thus diverted for considerable periods. Unusually high water has lately occurred in some of the lakes, as the dead pines at Eagle Lake and submerged fences at the head of Winnemucca Lake plainly indicate. Pyramid Lake was somewhat higher in 1911 than when seen by Russell,[b] as a comparison of his view of the tufa castle on the west shore of Pyramid Lake (Russell, pl. XL), and the photograph here presented (pl. IV, *b*) will show.

The insular position of the Lahontan system has been noted. On the east is the Bonneville, a similar system of interior drainage; on the north the Columbia, including Snake River; while on the west and south are the Klamath, Sacramento, San Joaquin, and Colorado systems. On the northwest, between the Lahontan and the Klamath and bordering the Columbia and Sacramento, is another region of interior drainage, the Oregon Lake system, a portion of the Great Basin to which reference will again be made.

DISTRIBUTION AND RELATIONSHIPS OF SPECIES.

Fifteen native species of fishes are now recognized in the Lahontan system. They are enumerated below and accompanied by page references to the "Fishes of North and Middle America,"[c] where an index to the literature pertaining to the various species may be found.

Catostomidæ.
- *Catostomus tahoensis* Gill and Jordan; *C. tahoensis*, p. 177.
- *C. arenarius*, new species.
- *Pantosteus lahontan* Rutter.
- *Chasmistes cujus* Cope; *C. cujus*, p. 183.

Cyprinidæ.
- *Richardsonius egregius* (Girard); *Leuciscus egregius*, p. 237.
- *R. microdon*, new species.
- *Siphateles obesus* (Girard); *Rutilus olivaceus*, p. 244; *R. symmetricus*, p. 245.
- *Leucidius pectinifer*, new species.
- *Agosia robusta* Rutter; *A. nubila carringtonii*, p. 311.

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[a] United States Geological Survey, Water Supply and Irrigation Papers, nos. 68, 133, 134, 176, 212, 220, 250, and 251.

[b] Department Interior, Monograph Geological Survey, vol. XI, 1885.

[c] Jordan and Evermann, Bulletin 47, United States National Museum, Washington.

Salmonidæ.

Coregonus williamsoni Girard; *C. williamsoni*, p. 463.
Salmo henshawi Gill and Jordan; *S. clarkii henshawi* (2819), p. 493; *S. clarkii tahoensis*, p. 2870.
Salmo aquilarum new species.
Salmo regalis Snyder.
Salmo smaragdus, new species.
Cottus beldingi Eigenmann; *C. beldingii*, p. 1958.

Of these, *Chasmistes cujus* is confined to Pyramid and Winnemucca Lakes, from which an annual spawning migration is made in the lower course of Truckee River. *Richardsonius microdon* is known from a few specimens caught with baited hook in Lake Tahoe. *Leucidius pectinifer* is lacustrine, breeding in the lakes and apparently never entering the rivers. *Salmo aquilarum* is a rainbow trout, which presumably entered Eagle Lake after the latter was detached from direct Lahontan drainage *S. regalis* and *S. smaragdus* are lacustrine. Their breeding habits are not known. The other species are generally distributed throughout the system.

In the presence of our limited knowledge of western fresh-water fishes it is confessed that an attempted discussion of the relationships of the Lahontan fauna is somewhat premature. A better acquaintance with the species in the headwaters of the Sacramento Valley streams and with those in the upper Columbia and the Snake Rivers is desirable, and something more should be known of the Bonneville fishes than has been recorded in their descriptions. However, it appears probable that, unless the purport of facts now at hand is wrongly interpreted, certain inferences may be drawn which will not be greatly altered by future investigation.

The position of the system being completely insular it may at once be assumed that the affinities of the Lahontan fishes are to be sought among the faunas of contiguous systems, and the assumption is well founded, as will be seen. When the relationships of a Lahontan species are apparent, they invariably are found to be with a form indigenous to a neighboring basin.

The Colorado River fauna does not appear to be directly represented in the Lahontan system. Among the Sacramento River fishes there are fine and coarse scaled catostomids similar to those of the Lahontan, a lake chub, *Siphateles formosus*, much like *S. obesus*, while the Sacramento and Lahontan species of *Agosia* and *Cottus* are distinguished with difficulty. The same may also be said of similar species found in the Klamath and Columbia Rivers, the near-related forms being enumerated in the following list:

Lahontan: *C. tahoensis*, *C. arenarius*, *S. obesus*, *A. robusta*, *C. beldingi*.
Sacramento: *C. microps*, *C. occidentalis*, *S. formosus*, *A. carringtoni*, *C. gulosus*.
Klamath: *C. rimiculus*, *C. snyderi*, *S. bicolor*, *A. klamathensis*, *C. klamathensis*.
Columbia: *C. catostomus*, *C. macrocheilus*, *S. columbianus*, *A. carringtoni*, *C. gulosus*.

However, it is when the Oregon Lake system is approached that we find species that are most closely related to those of the Lahontan, for an *Agosia*, a *Siphateles*, and a *Catostomus* are here which scarcely differ from representative forms found in the latter system. It therefore appears probable that certain species of the Lahontan fauna are most closely allied to those of the Oregon Lake system and through these to similar forms in the Sacramento, Klamath, and Columbia. The affinities of one Lahontan species, *Chasmistes cujus*, may be traced to Klamath Lake (fossils of the genus have been found in the Oregon Lake region) and, also, in the opposite direction to the Bonneville Basin of Utah, the only localities in which the genus has been found. *Pantosteus lahontan* closely resembles *P. platyrhynchus* of the Bonneville. The affinities of *Richardsonius egregius* seem to be with *R. balteatus* of the Columbia or with some similar form of the upper Snake River or the Bonneville. The relationships of *Richardsonius microdon* are not apparent, unless possibly they may be with *R. bicolor* of the Klamath or *R. caurinus* of the Columbia. *Cottus beldingi* and *C. semiscaber* have not been compared. The whitefish of the Lahontan and those of the Columbia apparently are alike.

It seems evident, then, that the fauna of the Lahontan system is related to that of the Oregon Lake, the Columbia, and the Bonneville systems. One, or possibly two, of the trouts may have come from the Sacramento. Of the latter, *S. aquilarum* is scarcely to be regarded as a Lahontan species.

Lahontan species.	Probable relationships.
Catostomus tahoensis	*Catostomus* of Sacramento, Klamath, or Columbia.
C. arenarius	*C. warnerensis*, Oregon Lake system.
Pantosteus lahontan	*P. platyrhynchus*, Bonneville.
Chasmistes cujus	*Chasmistes* of Klamath or Bonneville.
Richardsonius egregius	*R. balteatus*, Columbia.
R. microdon.	
Siphateles obesus	*S. oregonensis*, Oregon Lake system.
Leucidius pectinifer.	
Agosia robusta	*Agosia nubila carringtonii*, Oregon Lake.
Coregonus williamsoni	*C. williamsoni*, Columbia.
Salmo henshawi	*S. clarkii*, Columbia.
Salmo aquilarum	*S. irideus*(?), Sacramento.
S. regalis	*S. irideus*(?), Sacramento.
S. smaragdus.	
Cottus beldingi	*C. punctulatus* of Columbia or *C. semiscaber* of the Bonneville.

The Lahontan species are of necessity fluvial and lacustrine, although two genera, *Salmo* and *Cottus*, include representatives of forms which may be anadromous or at least able to pass through salt water. With one possible means of dispersal of fluvial fishes eliminated (the open ocean), one may conclude that the Lahontan fishes entered the system directly through channel connections or indirectly by stream capture. It is not presumed that lacustrine and channel forms which never migrate to the headwaters were brought into the system by stream capture, while on the other hand any native species may have entered it through a channel connection with another system. From what is at present known of the habits of the species it may be safely inferred that they reached the system as follows:

By channel connection: *C. cujus, R. microdon, S. obesus, L. pectinifer, S. regalis, S. smaragdus.*

By stream capture or channel connection: *C. tahoensis, C. arenarius, P. lahontan, R. egregius, A. robusta, S. henshawi, S. aquilarum, C. williamsoni, C. beldingi.*

Means of dispersal within the system become evident when the geology of the region is consulted.

THE GEOLOGY OF THE LAHONTAN SYSTEM AND ITS RELATION TO THE ICHTHYOLOGY.

The recent geological history of the Lahontan system has been worked out in a masterly way by Israel Cook Russell,[a] the results appearing in a large monograph published by the United States Geological Survey. Russell's account begins with Quaternary times, when Lake Lahontan covered a large and very irregular area, now mostly included within the State of Nevada. This great body of water, larger than Lake Erie, attained a maximum depth of 880 feet and received the discharge of numerous rivers, many of which flowed through narrow and deep mountain canyons. The history is continued down to the present time, when nothing is left of the ancient lake but the detached basins with which we are now concerned, mere desiccated remains scattered over a rock-bound waste of desert sands. Unmistakable traces of the old lake are to be seen on every hand, and they are particularly evident in the valleys of Pyramid and Winnemucca Lakes, where the eye of the observer can follow the ancient shore lines as they distinctly appear one above another for long distances up the mountain sides.

In the presence of this great body of water, to which the small river and lake basins of northern Nevada were all tributary at a relatively recent time, we may recognize a direct and simple explanation for the present distribution of the fishes now found there. But a part of Russell's investigation which also concerns the ichthyologist has to do with the question of an outlet of Lake Lahontan and, also, with the degree of desiccation to which the lake was subjected during its history. Quoting directly from Russell, and italicising statements of particular interest in this connection, we have (p. 250, chap. VII):

> The history of the fluctuations of the Quaternary lake of northwestern Nevada is recorded in various ways, as has been described in the last three chapters, which treat it from the physical, chemical, and biological standpoints. In the present chapter it is our purpose to present briefly the conclusions based upon these various lines of evidence. The phenomena observed have great diversity of character, but when interpreted in terms of geological history they support and supplement each other in such a way that the conclusions drawn are believed to be well sustained. Moreover, the facts observed in the Bonneville and in more than a score of desert valleys throughout the northern half of the Great Basin which contained contemporary water bodies harmonize with the interpretation of the Lahontan record here presented.
>
> The fact that all the minor basins in the arid regions of the Far West are filled to a depth of many hundreds of feet with alluvium and lacustral sediments, together with the occurrence of the beach lines of the Quaternary lakes on the surface of the vast alluvial cones, leads to the conclusion that *all these basins were barren deserts before the rise of the Quaternary lakes.* The pre-Lahontan condition of northwestern Nevada must have closely resembled its present character, *but at times it was probably completely desiccated.*
>
> The change of climate admitting of the existence and gradual expansion of lakes in the various valleys throughout the Great Basin caused a number of those situated in northwestern Nevada to rise sufficiently to unite and form a single irregular water body 8,922 square miles in area. This was the first rise of Lake Lahontan. Like all inclosed lakes it must have fluctuated in depth and extent with the alternation of arid and humid seasons and risen and subsided also in response to more general climatic ocellations, which extended through years and perhaps embraced centuries. Finally the climatic conditions which favored lake expansion ceased, and a time of aridity, like that which preceded the first rise, was initiated. The lake slowly contracted until *its basin reached a greater degree of desiccation than that now prevailing.* This was the inter-Lahontan period of desiccation.
>
> During the first rise lacustral marls and clays were deposited throughout the basin; the depth of these is unknown, but they certainly exceed 150 feet in thickness. The waters were saturated with

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[a] Department Interior, Monograph Geological Survey, vol. XI, 1885.

calcium carbonate, and the precipitation of great quantities of compact stony tufa took place. Deposits of tufa were formed on rocky slopes throughout the basin and are not especially abundant at the mouths of streams. This is thought to indicate that although the waters were saturated with calcium carbonate they were not highly charged with other chemical substances. This conclusion is sustained by observation of conditions under which a similar tufa is being deposited in existing lakes, and also by the presence of gasteropod shells in the lithoid tufa in great abundance.

The time of low water, and perhaps of complete desiccation, that succeeded the first rise of Lake Lahontan is recorded by stream channels carved in lacustral beds and by current-bedded gravels and sands superimposed upon previously formed strata. Sections of inter-Lahontan gravel deposits have been observed wherever the material filling the lake basin is well exposed, and furnish indisputable evidence that the lake was greatly lowered before the gravels were deposited. These gravels were in turn covered by a second lacustral deposit, thus forming a tripartite series, a counterpart of which exists in the Bonneville Basin. The first formed tufa deposit was exposed to subaerial erosion during the inter-Lahontan period of low water and became broken and defaced.

The character of the next succeeding tufa deposit indicates that a change had taken place in the chemical conditions of the waters of the lake when the basin was again partially flooded. The alteration in the composition of the salts dissolved in the lake is thought to have been brought about by a partial deposition of the saline matter accumulated during the first high-water stage at the time of the inter-Lahontan period of desiccation. The tufa superimposed upon the lithoid variety is known as thinolite; it is composed of well-defined crystals and is without fossils. It was evidently precipitated from a more highly concentrated chemical solution than that from which the lithoid variety was deposited. That this was the case was rendered evident, since the crystalline variety occurs only low down in the basin, while the lithoid tufa may be found within 30 feet of the highest terraces carved by the waters of the ancient lake.

After the crystallization of thinolite had been carried on for an indefinite period, the lake rose to within 180 feet of its first maximum, and the heaviest deposit of calcium carbonate found in the basin was precipitated. During this stage the lake was not strongly saline, as is shown by the abundance of gasteropod shells obtained from the sediments and tufas accumulated during this period of its history.

After the precipitation of the dendritic tufa the lake continued to rise and at last reached a horizon 30 feet higher than the first maximum. During this expansion the waters lingered but a comparatively brief time at the highest level and then slowly subsided. The increase in depth after the deposition of dendritic tufa is shown by the presence of lacustral sediments upon that deposit. The structure of the higher bars and embankments about the border of the old lake basin proves conclusively that the greatest lake expansion was during the second rise.

With the last recession of the lake all portions of its basin were brought within the reach of wave action, and the tufa deposits sheathing its interior were broken and the fragments swept away by currents and built into embankments and terraces. *The waters continued to fall until the basin was completely dry.* All the salts not previously precipitated were deposited as desiccation advanced and became buried and absorbed by playa clays. *The proof of the occurrence of this time of desiccation is furnished by the comparatively fresh condition of the existing lakes of the basin and by the change in the molluscan fauna which took place since the last high-water period. The duration of this post-Lahontan arid period is unknown, but it was finally terminated—probably less than 300 years since—by an increase in humidity. The present lakes then commenced their existence.*

It is evident, then, that Russell found, first, that Lake Lahontan had no outlet and, second, that there was a pre-Lahontan and a post-Lahontan period of complete desiccation, the latter prevailing to within the last 300 years.

The fish fauna of the Lahontan system may be termed characteristic, most of its species being distinct from related forms found elsewhere. One genus, *Leucidius*, is restricted to the system. These circumstances argue in favor of long isolation. Furthermore, the Lahontan species do not appear to be related to others of any particular system, contrary to what would be expected if the relatively recent Lake Lahontan had discharged its waters into another basin.[a] It thus appears that Russell's conclusion regarding the absence of an outlet fully explains the conditions here described. Further than this the present distribution of certain species does not seem to be in harmony with his interpretation of the geology, as will be indicated.[a]

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[a] The cases of Lake Bonneville and Malheur Lakes may be cited.

Chasmistes cujus is a lacustrine form known only from Pyramid and Winnemucca Lakes. The species lives in deep water beyond ocular observation except during the short breeding season, when great numbers of adult individuals pass up the Truckee to spawn. It is a large and clumsy fish (fig. 2) with relatively short fins and tail, not only physically unfit, but apparently unable, to stem the current of a very rapid stream. During the nuptial migration it does not go far beyond the great bend of the Truckee, selecting its spawning beds before the turbulent water of the river is encountered. It will be recalled that the only other species of the genus are found in Klamath and Utah lakes, and attention is also directed to the fact that they are likewise lacustrine fishes with habits similar to those of *C. cujus*. Complete desiccation of Pyramid and Winnemucca Lakes at the present time would certainly bring about the extermination of this species,[b] and it would, no doubt, have done so in the past. It therefore seems difficult to avoid the conclusion that the presence of this form in the basin prevents the acceptance of any hypothesis which does not recognize a complete continuity of Pyramid and Lahontan Lakes; and, moreover, an acceptable explanation of the present distribution of the species of the genus *Chasmistes* must of necessity assume a continuity between Lahontan and a still older lake or lakes which had at one time a channel connection with similar large bodies of water located elsewhere in the Great Basin. Also this body of water, continuous through a long period of time, must have been constantly fresh enough to support plant and animal life.

There is a trout indigenous to Pyramid and Winnemucca Lakes, *Salmo smaragdus* (described in the present paper), which can not be supposed to have recently differentiated. Not much is known of the habits of the species beyond that it does not appear in the rivers, and therefore apparently spawns in the lakes. The most nearly related species is probably *S. regalis* of Lake Tahoe, although it is very different. The turbulent Truckee appears to act as an impassable barrier to *S. smaragdus*, and there is no reason to suppose that it could survive the dessication of Pyramid and Winnemucca Lakes.

A theory involving the introduction and differentiation of such species since Quaternary times can scarcely be entertained at present, much less are we prepared to accept the supposition that they have appeared here within the last 300 years. Where there is any approximate measure of the time required in nature for the differentiation of a species, it is not a matter of hundreds of years, but rather of a long geological period of time.

A large number of species found in the Lahontan system are generally distributed, and it is therefore quite probable that these were introduced long before its separation into isolated basins—long enough for some of them to have become measurably differentiated from the parent stock. A careful examination of a large series of specimens has failed to detect any differentiation characteristic of the fishes of any particular basin of the system.

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[a] Recent discussions bearing more or less directly on this question may be noted here.

Snyder, J. O.: The fishes of the Lahontan drainage system of Nevada and their relation to the geology of the region. Journal, Washington Academy of Sciences, vol. IV, no. 11, p. 299; (extract), June 4, 1914.

Jones, J. Claude: The geologic history of Lake Lahontan. Science, n. s. vol. XL, no. 1040, Dec. 4, 1914.

Gale, Hoyt S.: Geologic history of Lake Lahontan, Science, n. s. vol. XLI, no. 1049, Feb. 5, 1915.

[b] The diversion of a considerable part of the Truckee may in the near future serve as a test for this supposition, unless the fall of Pyramid Lake is followed by a deepening of the river channel, which in turn would cut off the water supply of Winnemucca Lake and thus maintain Pyramid at a level not far below that of the present.

Eagle Lake appears to have been connected at one time with Lake Lahontan, as it contains two channel or lacustrine species, *Siphateles obesus* and *Leucidius pectinifer*, the latter of which has not been seen in the streams of Honey Lake Basin. It may be noted in this connection that *Salmo tahoensis*, the characteristic trout of the Lahontan system, is replaced in Eagle Lake by *S. aquilarum*, a form evidently derived from the rainbow trout of the western slopes of the Sierras, while the remaining native fishes of the lake are Lahontan species.

THE FOOD FISHES.

A discussion of the economic value of the fishes of this region and any consideration of methods of propagation and protection must begin and end with the assumption that agricultural and manufacturing interests are of paramount importance. A considerable and constantly increasing amount of the flowing water must be used first for power and then for irrigation, and when any measure intended for the protection of fishes is found to seriously interfere with the working of power plants or the demands of agriculture it will have to be abandoned. On the other hand, a strong sentiment prevails against the careless and unnecessary obstruction and pollution of rivers and lakes. It is coming to be generally recognized that factories and mills may operate without turning their refuse into the streams, dams may be so constructed as not to stop the passage of fishes during the spawning season, and irrigating ditches may be screened and thus prevent the loss of fishes in the fields.

Despite the arid conditions which prevail over the greater part of the region and the relative paucity of streams and lakes, the fishes and the sport of fishing are of considerable importance. Of the 15 native species, 6 are of more or less commercial value. These include the various trouts, the whitefish, and the "cui-ui." The last named is eaten by the Indians only, who profess to like them better than trout. Ten or more species have been introduced. Of these the carp, which has proved to be a positive nuisance, and the Mackinaw trout threaten to take the place of better varieties. The brook and the rainbow trouts thrive in suitable localities. Catfish and Sacramento sunfish are caught in considerable numbers. Formerly quantities of trout were shipped from Tahoe, Pyramid, Winnemucca, and Walker Lakes to the mining camps and even to San Francisco. At present fishermen supply the local market at Lake Tahoe and the Pyramid Indians sell trout at Reno, where the demand is said to be uncertain because of the irregular enforcement of laws.

Any suggestion which might be offered for the propagation and the adequate protection of the fishes of the region would include a close and continued observation of the habits of the native species, for conservation of fishes consists in the intelligent application of experience thus obtained, the arrest of poachers and the planting of fry being only incidental. Some of the difficulties in the way of proper protection here, and which are apparent to most observers, arise from the unfortunate circumstance that this system is included within the jurisdiction of two States, and that the viewpoint of those primarily interested in manufacture and agriculture does not always coincide with that of others who would protect wild life and in a measure preserve the rivers and forests from pollution and destruction.

The mills, with a few exceptions, attempt to keep the water clear, but they are not always careful to maintain a sufficient flow in the fishways. Small trout often pass out into the irrigation ditches, where proper screens are lacking in the mains, and considerable numbers of fishes are sometimes destroyed by the carelessness of those having charge of the large dams.[a]

Complaint has been made against water birds—the pelicans, cormorants, gulls, and terns—some of which have large breeding colonies on islands in the lakes. It is apparent, however, that but little harm is done by these birds, except that they consume food which might otherwise be available for the trout.

In the upper courses of the desert streams the trout, and all other fishes as well, are sometimes completely washed out or choked and killed as a result of sudden and violent thunderstorms, known as "cloud bursts," when a great quantity of water is precipitated on the mountain sides and, gathering force in the narrow gorges, sweeps everything before it, not even the fishes being able to withstand the terrific rush. The rise of a stream is sometimes so sudden that an advancing wall of water several feet in height plunges along the river bed uprooting trees and battering down other obstacles with rolling bowlders until at length it scatters everything pell-mell on the desert floor. When streams connect with the main channel at only infrequent intervals, some time usually intervenes between such a catastrophe and a natural restocking. Fortunately such occurrences are not frequent.

The possibilities of fish culture are relatively promising in this region, and considerable responsibility rests with those in control of the situation. Moreover, several species are threatened with extermination, and an attempt should be made to learn something more of their habits before the fishes entirely disappear.

SYSTEMATIC DISCUSSION OF SPECIES.

Catostomus tahoensis Gill and Jordan. Red sucker.

C. tahoensis is both fluvial and lacustrine and appears to be the most abundant sucker in the region living and spawning wherever the water is of sufficient depth.[b] During the spring and early summer its brilliant color, large size, and the commotion made by spawning individuals along the river bars, gravelly shores, and shallow lake beaches attract much attention. Breeding males are brassy above and on the sides, fading abruptly to dead white on the ventral surface. On the back the metallic color is obscured by small spots and specks of dark olive and black. A stripe five scales wide, brilliant dark vermilion in color, extends from the opercular opening to caudal, where it spreads out over the entire basal portion of the fin. There is a narrow, vertically oblong spot of the same bright color behind the eye and, also, a dash of it along edges of opercle. Below the stripe is a similar one of deep black, which causes both the red above and the white below to stand out in strong contrast. The dorsal is yellowish along the base and the paired fins have a yellowish tint. On turning in the clear water the fish's sides reflect the rays of the sun in flashes of crimson, gold, and silvery light. In holding this species in the hand the metallic tints are reflected from the fins and, in the most intensely colored individuals, from the ventral surface as well. The tubercles on the tail and anal fin are dead white. When not in nuptial color, the lateral stripes are metallic, orange, red, and blackish olive, respectively. The colors of the female are greatly subdued, the general pattern being the same, the whole body, olive above and light beneath, suffused with yellow, the darker areas deep olive or blackish. The lateral stripe is pinkish and not sharply defined. The fins are tinted with olive.

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[a] During the spring of 1912 the local papers contained accounts of the destruction of large numbers of trout in the Truckee River below the irrigation dam at Derby. The writer visited the place at the time and carefully examined the river from the town of Truckee to the mouth of the river. From the Derby dam and extending several miles down stream there were thousands of dead trout ranging in length from 2 to 3 or more feet, their decaying bodies strewn along the bars and clogging the ripples. The mortality was greatest within the first mile or two of the dam. There were hundreds of dead fishes above and below the station of Derby, and some were seen as far down as the great bend. An examination showed that many of these had spawned, while others had not. The cause of all this was evident beyond doubt. The river at the time was unusually low, following a winter of little rain and light snows in the mountains. At the very height of the spawning migration of the trout the impounding dam at Tahoe City was closed, and the gates allowing the water to pass into the canal leading from above the dam near Derby were opened, with the result that one could cross the lower Truckee dry shod. No trout could pass from the dam to Derby nor from there to the big bend nor from the big bend to the lakes. Trout could not even survive in the deeper pools between Derby and the dam because of their large numbers and the polluted water.

[b] It is worth while to note in this connection that *C. microps*, the fine-scaled sucker of the Sacramento, representative there of this species, is rare, but few specimens having been taken. Also that *C. rimiculus*, the fine-scaled form of the Klamath, is abundant in comparison with *C. snyderi*, which is rarely seen. It appears, then, that a fine-scaled form is able to thickly populate the streams of one basin while just the reverse occurs in another. It also will be recalled that a coarse-scaled form, *C. occidentalis*, which is more abundant in the Sacramento, has extended its range to Eel River and neighboring streams as *C. humboldtianus*, in which the scales are yet larger, and to the streams of Monterey Bay as *C. mniotiltus*, where the scales have also become larger. No representative of *C. microps*, the rarer Sacramento form, is known from these streams. Likewise, it is *C. rimiculus*, the more common form of the Klamath, but with fine scales, that has extended its range to the Rogue River.

The males appear first on the spawning beds and are always represented there in larger numbers, each female being attended by from two to eight or more. Twenty-five males were seen attending one female in a pool. Occasionally another female would enter the pool from below, when she would be met and inspected by a school of males and then allowed to pass on without further notice. Several of these passing females proved on examination not to be ripe. On account of the presence of so many males nothing definite can be observed of the spawning act, more than that the eggs are extruded and shaken down in the gravel by the female while the males struggle over and under her, churning the water to foam by their activities. Eggs artificially removed from a ripe female and quietly cast into the water upstream from the males attracted no more attention than did so much coarse sand. However, they were immediately gobbled up by numbers of *Richardsonius egregius*, which also attended the females, plunging into the melée of spawning fishes for eggs at every opportunity.

The bed, or nest, is a somewhat concave depression in the coarse sand or gravel, measuring from 1½ to more than 3 feet in diameter. The nest is located in shallow water, usually less than 12 inches deep, which often proves fatal to the young, for the falling water of the river uncovers the beds at times, and the eggs quickly perish in the hot sun. The eggs are found in large numbers deep among the pebbles. In spawning there is no opportunity for the female to make any selections among the males. Large and small males appear to have an equal opportunity in fertilizing the eggs, for no fighting occurs.

Spawning was in progress in the lower Truckee River April 22; Pyramid Lake May 20; ceased May 24; Eagle Lake May 25, the period about ended there; in tributaries of Lake Tahoe June 11.

Individuals of this species are very shy, the females being more difficult to catch than the males. When spawning they may be closely approached if one moves very slowly without producing any crunching of the gravel underfoot or allowing a shadow to fall on the water.

In the lakes this species attains a large size, one specimen measuring a little over 2 feet. The Indians call them "auwá-go," or "a-wuh," and occasionally catch them along with *Chasmistes*, but reject them as being undesirable for food. The flesh is sweet and palatable.

A very small specimen and a dried head of this species from Eagle Lake were described by Rutter as *Chasmistes chamberlaini*.[a] An inspection of the type and its comparison with prepared skulls of both *Catostomus* and *Chasmistes* leave no doubt as to its identity with the former. In fact, the describer suggested no reason for identifying it with *Chasmistes* or for supposing that it differed from *Catostomus*. Of the dried head the "prominent hump" of the snout, the inclined maxillary, and prominent nasal spines are not particularly characteristic of either *Chasmistes* or *Catostomus*. The skull of the type has a long and broad fontanel, the covering of "thin bone" mentioned in the description being merely dried skin. The small specimen has broad papillose lips.

A number of specimens were collected at Eagle Lake. They were taken from a large school which was spawning in a favorable place on the northeast shore. Males were largely in the majority, and the females were so wary that none could be taken in the nets even after great perseverance. The water being cold and clear rendered difficult the task of getting even the males. On these the light lateral stripe was orange red, with a broken outline, varying in width from five to six or seven scales.

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[a] Bulletin United States Fish Commission, vol. XXII, 1902, p. 147.

The dorsal fin was dark olive, pectorals and ventrals tinted with yellowish pink, lips yellowish white, iris brassy. No difference could be found in specimens of this species from Eagle Lake and those from the Lahontan system.

In the rivers this species is very numerous. Where the water contains much silt they are light in color, often very pale olive, with a considerable amount of light yellow. Late in the season the red stripe seems to almost entirely disappear from the males and it is not seen at all in the females. The young have several dusky spots on the sides.

The affinities of this catostomid will be considered with those of the following species, *C. arenarius*.

Measurements and scale counts are given here, numerous in this case because the Eagle Lake specimens are included in the species.

Scales in lateral series	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Fallen Leaf Creek	....	....	1	2	1	1	3	6	5	7	7	2	1	2	2	....
Truckee River	1	1	1	1	1	....	2	1	3	5	2	1	2	1	....	....
Humboldt River, Palisade	....	....	....	....	....	2	....	2	2	6	4	4	1	1	....	....
Humboldt River, Carlin	....	....	....	....	3	....	....	1	....	1	1	....	2	1	1	....
Little Humboldt River	1	....	....	1	1	1	....	1	....	1	....	1	2	....	....	....
Pine Creek, Palisade	....	....	....	....	....	1	3	1	....	3	1	....	....	....	....	....
Star Creek, Deeth	....	....	....	2	1	....	1	1	2	5	3	....	2	1	1	1
Walker River	....	....	....	1	3	3	6	3	5	4	....	1	1	....	....	....
Specimens observed	2	1	2	7	10	8	15	16	17	32	18	9	11	6	4	1
Series of scales above lateral line	....	....	....	....	....	....	....	....	....	....	....	16	17	18	19	20
Number of specimens observed	....	....	....	....	....	....	....	....	....	....	....	2	23	28	15	1
Scales in series below lateral line	....	....	....	....	....	....	....	....	....	....	....	....	12	13	14	15
Number of specimens observed	....	....	....	....	....	....	....	....	....	....	....	....	1	24	34	10

The measurements recorded in the following pages were made by means of dividers and a proportional scale. They are expressed in hundredths of the length of the body (which is recorded in millimeters), measured from the tip of the snout to the end of the last caudal vertebra.

The length of the head is measured from the snout to the posterior edge of the opercle, the opercular flap, which is apt to shrink, not being considered. Depth head, measured at occiput. Depth body, the greatest depth. Snout to dorsal; snout to ventral, from tip of snout to anterior end of base of fin. Depth caudal peduncle, at the narrowest place. Length of caudal peduncle, base of posterior anal ray to end of last vertebra, not to base of lowermost caudal ray, as the latter point is often indefinite. Length of snout, tip of snout to anterior border of eye. Interorbital width measured on skull, the dividers being closed as nearly as possible between the eyes. Snout to occiput, tip of snout to point on occiput where scales begin. Length base of dorsal or anal, distance between bases of first and last rays. Length caudal, from end of last vertebra to tip of upper lobe. Scales lateral line, counted to end of last vertebra. Scales above lateral line, from lateral line upward and forward to a point near middle of back. Scales below lateral line, from anterior edge of base of anal upward and forward to lateral line; lateral line series not included in either count. Scales before dorsal, the number of rows between base of first dorsal ray and the occiput. Dorsal and anal rays, when the posterior ray is cleft to the base it is still counted as one. The anterior ray is often spinelike and preceded by one or more closely adnate simple rays. These are enumerated as one.

MEASUREMENTS OF CATOSTOMUS TAHOENSIS.

FALLEN LEAF CREEK, NEAR LAKE TAHOE.

Length of body.....mm..	193	185	177	169	202	181	142	176
	♂	♂	♂	♂	♀	♀	♀	♀
Length head	0.25	0.24	0.255	0.245	0.25	0.235	0.24	0.23
Depth body	.18	.18	.20	.20	.20	.21	.20	.21
Depth caudal peduncle	.075	.075	.08	.08	.083	.08	.095	.08
Length caudal peduncle	.163	.16	.17	.155	.175	.17	.16	.17
Length snout	.12	.115	.12	.12	.13	.11	.12	.11
Diameter eye	.04	.045	.045	.042	.04	.042	.045	.04
Interorbital width	.08	.08	.09	.085	.09	.085	.085	.085
Depth head	.15	.155	.16	.16	.155	.16	.16	.155
Snout to occiput	.205	.19	.22	.21	.215	.20	.20	.205
Snout to dorsal	.51	.50	.51	.52	.51	.48	.51	.51
Snout to ventral	.565	.55	.56	.55	.555	.55	.58	.54
Length base of dorsal	.13	.15	.13	.15	.12	.125	.125	.14
Length base of anal	.095	.08	.10	.095	.08	.075	.07	.08
Height dorsal	.15	.155	.16	.175	.155	.17	.175	.16
Height anal	.21	.205	.24	.23	.19	.19	.20	.17
Length pectoral	.18	.19	.21	.21	.18	.19	.20	.18
Length ventral	.165	.15	.125	.13	.125	.135	.14	.125
Length caudal	.20	.21	.235	.235	.21	.21	.235	.21
Dorsal rays	10	11	10	11	10	10	10	10
Anal rays	7	7	7	7	7	7	7	7
Scales lateral line	90	95	89	89	91	92	88	94
Scales above lateral line	17	19	17	19	18	18	17	18
Scales below lateral line	13	14	13	13	14	13	14	14
Scales before dorsal	48	50	50	46	50	45	45	49

TRUCKEE RIVER NEAR MOUTH.

Length of body.....mm..	217	197	230	290	275	278	308	310	290	295
	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀
Length head	0.22	0.235	0.23	0.23	0.22	0.235	0.23	0.23	0.235	0.225
Depth body	.19	.20	.22	.185	.205	.20	.20	.19	.18	.20
Depth caudal peduncle	.09	.085	.095	.08	.095	.09	.09	.08	.085	.09
Lenght caudal peduncle	.18	.17	.17	.16	.16	.17	.17	.16	.16	.17
Length snout	.11	.12	.11	.115	.11	.11	.105	.115	.115	.11
Diameter eye	.034	.04	.035	.035	.03	.035	.032	.03	.032	.03
Interorbital width	.09	.09	.10	.09	.10	.10	.10	.10	.095	.10
Depth head	.15	.16	.16	.155	.145	.16	.17	.155	.155	.16
Snout to occiput	.18	.21	.19	.19	.175	.19	.18	.185	.20	.18
Snout to dorsal	.48	.50	.49	.495	.49	.495	.49	.51	.51	.50
Snout to ventral	.56	.55	.55	.58	.545	.57	.55	.57	.56	.57
Length base of dorsal	.145	.15	.165	.145	.165	.145	.13	.13	.13	.12
Length base of anal	.10	.09	.10	.09	.10	.08	.082	.071	.075	.085
Height dorsal	.16	.17	.16	.145	.15	.15	.15	.135	.14	.145
Height anal	.19	.21	.225	.16	.185	.19	.18	.165	.17	.182
Length pectoral	.195	.20	.19	.175	.175	.185	.175	.17	.155	.175
Length ventral	.145	.16	.16	.15	.15	.135	.13	.125	.12	.13
Length caudal	.20	.22	.22	.20	.21	.20	.205	.19	.18	.21
Dorsal rays	11	10	11	11	11	11	11	11	10	10
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	89	88	82	89	84	93	83	90	90	91
Scales above lateral line	16	17	17	17	17	18	17	18	17	16
Scales below lateral line	14	14	14	14	13	15	14	13	15	15
Scales before dorsal	43	41	43	44	41	44	41	45	44	43

Measurements of Catostomus tahoensis—Continued.

HUMBOLDT RIVER NEAR PALISADE.

Length of body.....mm..	178	173	157	153	147	123	130	135	134	123
Length head	0.23	0.25	0.24	0.26	0.23	0.25	0.24	0.25	0.255	0.235
Depth body	.175	.18	.18	.175	.17	.19	.21	.175	.20	.20
Depth caudal peduncle	.09	.095	.085	.085	.08	.085	.095	.085	.09	.09
Length caudal peduncle	.15	.15	.15	.15	.17	.16	.15	.155	.155	.15
Length snout	.115	.12	.11	.125	.11	.11	.11	.12	.12	.11
Diameter eye	.04	.045	.04	.045	.04	.045	.045	.045	.045	.045
Interorbital width	.095	.095	.095	.095	.09	.09	.10	.09	.10	.10
Depth head	.15	.16	.16	.16	.16	.155	.17	.16	.17	.16
Snout to occiput	.20	.21	.21	.215	.20	.205	.21	.21	.21	.20
Snout to dorsal	.52	.51	.51	.52	.50	.52	.51	.51	.51	.51
Snout to ventral	.59	.575	.57	.58	.565	.56	.56	.555	.57	.57
Length base of dorsal	.13	.14	.12	.13	.125	.14	.135	.12	.13	.13
Length base of anal	.07	.065	.065	.075	.062	.06	.065	.065	.06	.07
Height dorsal	.16	.17	.165	.165	.17	.17	.165	.175	.18	.175
Height anal	.19	.19	.19	.215	.195	.21	.18	.175	.19	.21
Length pectoral	.19	.19	.185	.20	.18	.20	.18	.19	.20	.21
Length ventral	.15	.15	.14	.145	.14	.15	.13	.14	.14	.16
Length caudal	.24	.28	.22	.24	.22	.24	.23	.225	.25	.225
Dorsal rays	10	11	10	10	10	11	10	10	10	10
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	91	86	90	92	91	92	89	90	88	90
Scales above lateral line	17	17	18	19	19	19	19	18	17	18
Scales below lateral line	14	12	14	14	13	13	13	13	13	13
Scales before dorsal	45	40	44	43	40	44	42	43	40	41

WALKER RIVER, YERINGTON, NEV.

Length of body.....mm..	158	160	148	142	131	127	140	135	126	122
Length head	0.235	0.235	0.24	0.23	0.245	0.23	0.22	0.24	0.24	0.26
Depth body	.22	.20	.21	.21	.20	.20	.21	.21	.20	.20
Depth caudal peduncle	.095	.09	.10	.10	.085	.10	.09	.09	.09	.095
Length caudal peduncle	.16	.17	.17	.16	.15	.18	.15	.16	.155	.15
Length snout	.11	.11	.11	.11	.115	.10	.105	.12	.11	.12
Diameter eye	.04	.04	.04	.04	.045	.045	.04	.04	.04	.04
Interorbital width	.10	.09	.095	.10	.10	.095	.09	.10	.095	.10
Depth head	.155	.155	.16	.15	.155	.16	.15	.16	.16	.16
Snout to occiput	.195	.195	.20	.20	.205	.185	.21	.20	.20	.21
Snout to dorsal	.49	.495	.485	.50	.50	.49	.475	.50	.50	.505
Snout to ventral	.56	.57	.565	.565	.57	.56	.545	.57	.57	.56
Length base of dorsal	.15	.15	.14	.14	.13	.13	.15	.14	.14	.14
Length base of anal	.085	.08	.08	.085	.08	.075	.08	.08	.075	.08
Height dorsal	.175	.175	.19	.16	.16	.19	.16	.18	.18	.17
Height anal	.21	.19	.22	.20	.20	.22	.19	.19	.225	.20
Length pectoral	.205	.20	.22	.20	.21	.21	.20	.21	.215	.18
Length ventral	.15	.145	.17	.15	.14	.16	.145	.15	.16	.15
Length caudal	.23	.215	.21	.22	.24	.23	.22	.23	.23	.24
Dorsal rays	10	11	11	11	10	11	11	11	11	10
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	89	87	92	86	88	87	85	85	89	84
Scales above lateral line	18	16	19	18	17	17	17	19	18	19
Scales below lateral line	13	14	15	15	14	14	14	15	15	15
Scales before dorsal	45	45	41	44	44	43	42	42	45	46

MEASUREMENTS OF CATOSTOMUS TAHOENSIS—Continued.

EAGLE LAKE, CALIFORNIA.

Length of body.....mm..	341	362	325	325	276	335	332	285	297	261
	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂
Length head	0.24	0.235	0.25	0.24	0.24	0.24	0.23	0.24	0.235	0.245
Depth body	.215	.205	.205	.215	.219	.205	.205	.195	.22	.215
Depth caudal peduncle	.09	.085	.095	.085	.085	.09	.085	.085	.095	.085
Length caudal peduncle	.145	.16	.15	.15	.165	.15	.15	.14	.14	.16
Length snout	.115	.115	.12	.12	.115	.115	.12	.12	.115	.115
Diameter eye	.032	.032	.035	.031	.035	.032	.032	.035	.032	.035
Interorbital width	.11	.105	.11	.105	.105	.105	.105	.105	.10	.10
Depth head	.17	.17	.17	.165	.165	.165	.165	.17	.165	.17
Snout to occiput	.19	.205	.20	.20	.195	.205	.195	.195	.20	.215
Snout to dorsal	.48	.50	.49	.51	.49	.485	.485	.51	.48	.485
Snout to ventral	.55	.56	.57	.56	.57	.55	.565	.575	.55	.57
Length base of dorsal	.15	.14	.15	.14	.14	.14	.155	.14	.162	.15
Length base of anal	.10	.10	.105	.095	.09	.095	.10	.09	.10	.10
Height dorsal	.15	.14	.15	.15	.16	.145	.15	.14	.15	.145
Height anal	.19	.17	.195	.19	.20	.19	.195	.195	.185	.185
Length pectoral	.20	.185	.19	.185	.185	.175	.18	.195	.19	.18
Length ventral	.13	.13	.13	.14	.14	.13	.14	.14	.14	.14
Length caudal	.205	.21	.20	.20	.205	.185	.195	.205	.195	.19
Dorsal rays	11	10	11	10	11	11	11	11	11	11
Anal rays	7	7	7	7	7	7	8	7	7	7
Pectoral rays	14	14	15	15	16	15	16	16	16	15
Scales lateral line	89	93	93	90	94	92	96	93	95	94
Scales above lateral line	19	20	21	21	21	20	21	21	21	20
Scales below lateral line	16	16	15	16	15	16	16	16	16	16
Scales before dorsal	44	43	45	45	46	50	48	49	50	48

Catostomus arenarius, new species. Sand-bar sucker.

Examples of the species, which is here described for the first time, resemble those of *C. tahoensis* so closely as to easily pass unnoticed among them. The scales of *C. arenarius* are larger, however. This species is apparently a representative of *C. macrocheilus*, *C. snyderi*, and *C. occidentalis*, all similar coarse-scaled forms of the Columbia, Klamath, and Sacramento River systems, respectively. It should not be regarded as a very close ally of either *C. catostomus*, *C. rimiculus*, or *C. microps*. It differs but little from *C. warnerensis* of the Oregon Lake system, and it is possible that the immediate relationships of that form may be with this species rather than with *C. catostomus* or *C. tahoensis*. *C. arenarius* has smaller scales than are found in *C. macrocheilus*, *C. snyderi*, or *C. occidentalis*. In addition to the smaller scales it has fewer dorsal rays than are found in *C. occidentalis* or *C. snyderi*.[a]

When its relationships are considered, the discovery of this species becomes a matter of considerable interest, for it adds an important link to the chain of related catostomid species which are known to occur in the Sacramento, Klamath, Columbia, and Lahontan systems. The following diagram will serve to illustrate the probable affinities and distribution of these forms:

Coarse-scaled catostomids	Sacramento	*C. occidentalis.*
	Klamath	*C. snyderi.*
	Columbia	*C. macrocheilus.*
	Oregon Lake	*C. warnerensis.*
	Lahontan	*C. arenarius.*
Fine-scaled catostomids	Sacramento	*C. microps.*
	Klamath	*C. rimiculus.*
	Columbia	*C. catostomus.*
	Lahontan	*C. tahoensis.*

It has been suggested that the lake region of eastern Oregon[b] may in the remote past have furnished a free way for the migration of both a fine and a coarse scaled catostomid, which became differentiated after entering the systems where its representatives are now found. But one species, *C. warnerensis*, has been taken in the Oregon Lake region, the other, if such really existed, having been unable to maintain itself in the very restricted and reduced basins of which the system is now composed. It seems that *C. warnerensis* and *C. arenarius* are probably related, both belonging with the coarse-scaled series.

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[a] Bulletin, United States Bureau Fisheries, vol. XXVII, 1907, p. 80–84, 161–169.

[b] Bulletin, United States Bureau Fisheries, vol. XXVII, 1907, p. 77.

The following description is of the type, no. 75654, United States National Museum, a male specimen measuring 330 millimeters, collected at the Willows, Pyramid Lake, Nev., May 20, 1913. (Fig. 1.)

Head 4.1 in length to base of caudal; depth 4.9; depth caudal peduncle 11.5; snout 2.1 in head; eye 7.2; interorbital space 2.5; width of mouth 4.2; scales lateral series 75; between lateral line and back 15; between lateral line and base of ventral 12; between occiput and dorsal 26.

Mouth large, the lips broad and full; 6 or 7 rows of papillæ on upper lip, about 8 on the lower. Eye nearer edge of opercle than tip of snout. The dorsal foramen of the skull is broad and long. Body completely scaled, the scales being nowhere unusually small or densely crowded; those on anterior part of breast deeply embedded and not easily distinguished. Edge of dorsal fin straight. Ventrals inserted below middle of dorsal. Pectorals, ventrals, and anal broadly rounded.

Color in life, olive above, light yellowish brown on the sides, silvery suffused with pink on the ventral surface, back, and sides with metallic reflections; a bright red lateral stripe of irregular width and with indefinite edges extends from opercle to tip of tail; tubercles on anal and lower half of caudal dead white. In spirits all trace of the bright color disappears; the dorsal parts become blue-black, then brown, the ventral region white or yellowish.

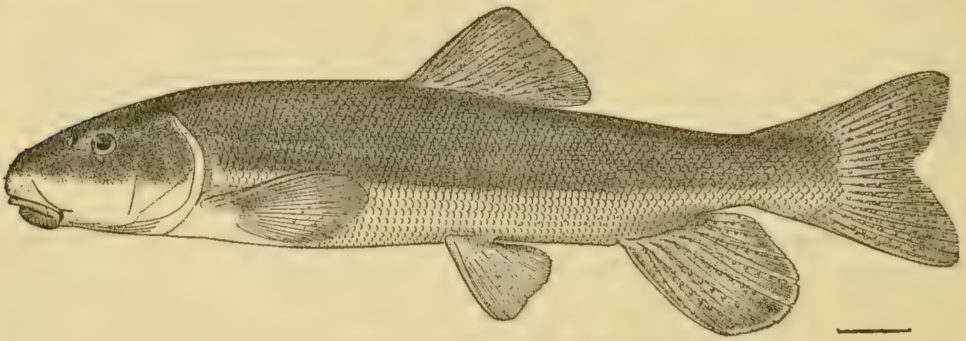

FIG. 1.—*Catostomus arenarius.* Type. Sand-bar sucker.

The females are less brightly colored in life, the body lacking much of the metallic sheen, and the lateral stripe being but faintly indicated. On attaining large size the body becomes stocky and the head appears more rounded. The largest specimen seen measured 20 inches in length and weighed 2½ pounds.

The first example of this species was seen in the lower Truckee River, where it was picked out from a number of "cui-ui" and red suckers caught by the Indians. They called it "au-wá-go," not distinguishing between it and the red sucker, *C. tahoensis.* It was later caught in Fallen Leaf Creek near Lake Tahoe and in the Humboldt River. It was finally observed spawning in Pyramid Lake, May 20. The eggs were being deposited deep in the coarser sand and gravel of the bars near shore. Numerous minnows were in attendance struggling with one another for the eggs. After June 1 no suckers were spawning and none was seen near shore.

One large example of this species was found in the collection of the National Museum among some specimens of *Catostomus tahoensis* which had been collected long ago by H. W. Henshaw at Lake Tahoe.[a]

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[a] *Catostomus tahoensis* first appears in Bulletin 12, United States National Museum, 1878, p. 173, where a brief diagnosis is given, and a specimen collected by J. G. Cooper is designated as the type. Examples collected by Henshaw are also mentioned. A description and figures appear later (Report Chief Engineers, 1878, pt. 3, p. 1610), where the specimens collected by Henshaw are referred to as the types. However, the figures accompanying this description are of one of the examples collected by Cooper, and which was first designated as the type. It is fortunate that the latter is preserved (type no. 5240), for an examination of Henshaw's specimens reveals the presence of two species, one of which, a relatively fine-scaled form, is represented by Cooper's specimen. The latter measures 298 millimeters in length. There are 92 scales in the lateral series, 16 between the lateral line and the back and 50 between the occiput and dorsal fin. The name *tahoensis* may without doubt therefore be applied to the fine-scaled form.

MEASUREMENTS OF EIGHT SPECIMENS OF CATOSTOMUS ARENARIUS.

Length of body.......mm..	294	308	282	419	157	140	126	117
Length head	0.27	0.265	0.25	0.26	0.235	0.245	0.24	0.235
Depth body	.215	.23	.21	.21	.19	.21	.20	.225
Depth caudal peduncle	.09	.09	.09	.08	.08	.09	.08	.09
Length caudal peduncle	.155	.175	.165	.155	.16	.165	.155	.17
Length snout	.135	.12	.12	.13	.115	.11	.115	.11
Diameter eye	.035	.032	.035	.03	.045	.045	.045	.04
Interorbital width	.12	.105	.10	.115	.085	.09	.10	.095
Depth head	.18	.172	.17	.175	.15	.16	.16	.15
Snout to occiput	.21	.20	.21	.205	.21	.21	.21	.195
Snout to dorsal	.515	.49	.515	.50	.50	.51	.55	.50
Snout to ventral	.59	.575	.565	.58	.56	.565	.57	.58
Length base of dorsal	.132	.14	.14	.13	.15	.125	.14	.13
Length base of anal	.08	.075	.09	.085	.095	.08	.08	.08
Height dorsal	.145	.145	.15	.13	.16	.155	.165	.18
Height anal	.18	.182	.21	.165	.22	.19	.19	.20
Length pectoral	.20	.185	.20	.19	.21	.18	.20	.20
Length ventral	.135	.133	.145	.13	.17	.14	.16	.15
Length caudal	.23	.21	.23	.19	.225	....	.23	.23
Dorsal rays	11	11	11	11	11	10	10	10
Anal rays	7	7	7	7	7	7	7	7
Scales lateral line	68	73	75	73	73	74	73	74
Scales above lateral line	15	16	14	16	16	15	14	16
Scales below lateral line	12	11	12	11	12	13	12	13
Scales before dorsal	35	34	36	36	40	40	41	39
No. [a]	1	2	3	4	5	6	7	8

[a] No. 1-3, Pyramid Lake; 4, Truckee River near Pyramid Lake; 5, Fallen Leaf Creek near Lake Tahoe; 6, Humboldt River, Carlin; 7, Pine Creek near Palisade; 8, Star Creek near Deeth.

Pantosteus lahontan Rutter. Lahontan sucker.

The relationships of the Lahontan sucker were thought by its describer to be with *Pantosteus generosus* of the Bonneville system.[a] An examination of the types of the suckers described from the Bonneville Basin, and which have been lately regarded as synonymous with *P. generosus*, reveals the presence of two species which appear to be generically different, *Notolepidomyzon generosus* (Girard) and *Pantosteus platyrhynchus* (Cope). The affinities of *P. lahontan* are with the latter. It has an open fontanel and a long slender form like that of *P. platyrhynchus*. A series of carefully prepared specimens of *P. platyrhynchus* is not available for a more detailed comparison of the species.

The cutting edges of the mouth are provided with sharp, horny coverings. The lips are pendulous and have many prominent papillæ. The posterior lip is not deeply cleft, the papillose area opposite the notch extending forward toward the center. The pectorals are pointed and somewhat falcate. The anal frequently extends to the base of the caudal.

In life, examples of this species are usually brownish olive above, of a lighter or darker shade, depending much on the surroundings, and lighter to whitish beneath. Often a pale-red lateral stripe appears after death in alcohol. Several males were observed with a bright-red lateral stripe, about equal in width to the eye, extending along the side from middle of head to caudal fin, the color becoming brighter in the region between the head and dorsal fin. The body was light olive above with brassy reflections, lighter on the sides, merging into silvery and then into dead white below. The fins were brassy, the axils of pectorals and ventrals orange red. Anal fin and lower half of caudal with dead white tubercles. Peritoneum dense black.

The alimentary canal is very slender, extremely long, and regularly coiled over the ventral surface of the abdomen. The air bladder extends over about three-fourths of the length of the abdominal cavity. Its anterior chamber is somewhat less than one-third as long as the posterior part.

Females with nearly ripe eggs were observed in Long Valley Creek, July 13. Ripe eggs were found in examples in Carson River, July 20, and in Quinn River, July 30. Both males and females appeared to be migrating up the Humboldt River early in July, for they were congregating in large number below obstructions.

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[a] Bulletin, United States Fish Commission, vol. XXII, 1902, p. 146.

This species appears in schools along with *Catostomus*, small examples of the latter being easily distinguished in the water by the large dark spots on the sides. It usually appears in small numbers in the lower courses of the streams, but is often more abundant where the current is swift. Individuals do not appear to reach a large size; no specimen over 6 inches in length was seen. None was found in the lakes.

Small suckers which may belong to this species were reported from Pine Creek, which flows into Eagle Lake. None was seen at the time of the writer's visit.

MEASUREMENTS OF PANTOSTEUS LAHONTAN, HUMBOLDT RIVER, PALISADE.

Length of body.................mm..	121	129	123	127	124	118	100	108	98	110
Length head	0.23	0.21	0.23	0.22	0.23	0.225	0.21	0.23	0.215	0.22
Depth body	.19	.17	.17	.18	.17	.18	.20	.165	.165	.16
Depth caudal peduncle	.085	.08	.08	.08	.08	.08	.08	.08	.08	.08
Length caudal peduncle	.16	.16	.165	.17	.165	.155	.165	.17	.17	.16
Length snout	.12	.11	.125	.125	.125	.115	.11	.12	.12	.115
Diameter eye	.04	.04	.04	.04	.04	.045	.04	.04	.04	.04
Interorbital width	.08	.08	.08	.085	.08	.08	.08	.075	.08	.075
Depth head	.14	.13	.135	.14	.14	.135	.135	.13	.14	.13
Snout to occiput	.20	.18	.205	.205	.20	.20	.20	.20	.19	.20
Snout to dorsal	.50	.49	.50	.50	.49	.49	.50	.50	.49	.50
Snout to ventral	.575	.55	.56	.57	.58	.56	.57	.58	.56	.565
Length base of dorsal	.14	.13	.13	.13	.125	.145	.13	.135	.13	.14
Length base of anal	.06	.063	.065	.07	.165	.07	.06	.065	.07	.065
Height dorsal	.16	.17	.16	.16	.16	.165	.17	.18	.16	.16
Height anal	.20	.225	.21	.20	.215	.21	.21	.20	.20	.20
Length pectoral	.19	.20	.19	.20	.20	.20	.19	.20	.20	.18
Length ventral	.14	.145	.14	.14	.145	.145	.13	.15	.14	.15
Length caudal	.22	.22	.215	.22	.215	.215	.21	.22	.20	.22
Dorsal rays	10	11	10	10	10	11	10	10	10	10
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	78	83	77	79	83	82	83	82	81	80
Scales above lateral line	15	16	18	16	17	16	18	16	15	16
Scales below lateral line	11	12	13	12	12	13	13	12	11	12
Scales before dorsal	40	41	42	41	43	44	44	44	42	43

Chasmistes cujus Cope. "Cui-ui."

Nothing seems to have been added to the brief original description of this species given by Cope,[a] and until now but one specimen, the type, was preserved in any museum. Its distribution is restricted to Pyramid and Winnemucca Lakes, where it lives in deep water beyond the reach of ocular observation, except during the brief spawning period, when a migration is made for a short distance up the Truckee River.

The annual run begins about April 15, varying somewhat of late years with the condition of the river. The season of 1913 afforded an unusually good opportunity for observation, as the water was comparatively low and clear, while during the entire spring a reasonably steady flow into both Pyramid and Winnemucca Lakes was maintained.

The first "cui-ui" appeared in the river April 13, when several schools passed up rather hastily and lodged in pools below an impassible irrigation dam. This preliminary wave having passed, none was seen again until on the morning of April 22, when schools of 20, 30, or even 50 or more individuals were observed moving slowly and steadily upstream. It was customary for them to congregate and lie for a while below a rapid place, then suddenly and speedily shoot up, singly or in pairs or in small straggling schools, their brilliant red and brassy sides flashing in the bright sunshine. None of these stopped to spawn. Some which were dissected did not appear to be ripe. They were very shy and fled at once on the approach of a shadow, the jar of crunching gravel, or a heavy footfall; but the observer could come close if the move was steadily made. The passage of large numbers continued intermittently, until about May 16, when it became evident that the migration was waning rapidly. After May 11 none was seen moving upstream.

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[a] Proceedings, Academy Natural Sciences, Philadelphia, 1883, p. 149:

Cope spelled the Piute name of the species *Couia*, and it has been thus known to recent authors. The white residents pronounce it *kwee-wee*. Both the latter and Cope's name are corruptions of the Indian name "Cui-ui" (pronounced *Kouie-wee*).

Fowler holds that *Lipomyzon*, Cope, 1879 (*brevirostris*) should be used instead of *Chasmistes* (Jordan, 1879) (Proceedings, Academy Natural Science, Philadelphia, 1914, p. 53). It will be found, however, that Dr. Jordan (Bulletin, Geological Survey, Hayden, vol. IV, 1878, p. 417) fully, or at least sufficiently diagnosed the genus *Chasmistes* as follows: "This genus is distinguished from *Catostomus* by the very large terminal mouth, the lower jaw being very strong, oblique, its length about one-third that of head. The lips in *Chasmistes* are little developed and are very nearly smooth."

Dr. Jordan wrongly supposed that the specimens from which he described *Chasmistes* were representatives of *Catostomus fecundus* Cope and Yarrow, the type of which he had not then seen, and which, as he later determined, is a true *Catostomus*. Under the circumstances it seems to be of secondary importance that *C. fecundus*, the name wrongly applied, was first designated as the type. (Bulletin, United States National Museum, no. 12, 1878, p. 219.)

In the meantime spawning had begun and was progressing with great activity. On April 24 the first females were seen depositing eggs. However, several ripe males and females were secured a little earlier. By May 5 every suitable bar or gravel bed was occupied by spawning fishes, whose activities entirely ceased before the 16th.

The spawning is entirely suckerlike; it occurs in relatively shallow water where the flow is rapid, often at the head of a bar which turns or parts the current. At times the dorsal fins project above the surface, and in very shallow places where there is much crowding the whole back is exposed. Two, three, or even five or more males attend a single female during the spawning act. They wriggle over, alongside of, and around her, thrashing the water with such violence that close observation is impossible. Spawning fishes are easily alarmed, but if the observer approaches in the water he may occasionally get close enough to pick up specimens without difficulty. Eggs may be stripped and fertilized with ease.

The ovaries are large, the eggs small and very abundant. No enemy appeared on the spawning beds, but the habit of depositing the eggs in shallow water often exacts an enormous toll from the young of the species, for a sudden fall in the volume of the river may leave many nests high and dry in a single day.

No doubt the migration and spawning activities here described are fairly typical. Usually the water is so high, swift, and roily that very little of what is going on beneath its surface can be seen. Of late years irrigation projects and power plants have at times seriously interfered with the flow of the river and consequently disturbed the normal life of some of its native species. During the winter of 1911–12 the snow was very light in the mountains and there were no heavy rains. The dam at Tahoe was closed early, and a large amount of water was at the same time diverted from the channel of the Truckee above Derby. The lower part of the river then became so reduced that water began to flow back from Pyramid Lake (where it was higher than usual), up the river, down the slough, and into Winnemucca Lake, the surface of which is lower than that of Pyramid Lake. This flow continued until the water of the channel between the lakes was practically as brackish as that of the lakes themselves. No "cui-ui" appeared in the river until a full month after the usual time, and then not until high water suddenly forced back the brackish flow and sent a fresh stream out into the lake. On the advent of this directing current the usual rush of "cui-ui" from the lakes began; large schools passed up the river (May 17) and spawned at once. During the earlier back flow sufficient depth was maintained for the easy passage of the fish, but it seems probable that there being no inflow of fresh water the waiting migrants were unable to find the mouth of the river.

The time of departure of the fish from the river could not be determined because of high water, as no "cui-ui" were seen at any time going down stream. A few individuals were seen in the river June 14, when the water suddenly cleared. On June 5, and for many days thereafter, large numbers of dying, dead, and decaying specimens were found at the mouth of Winnemucca Slough. This mortality among the "cui-ui" is said to be a regular feature of the season at this place. If a similar death rate prevails in the lower Truckee, it was not evident at the time. However, the river was deep, the current strong, and the lake was stormy when the examination was made. A few dead individuals are always found along the river after the breeding season. It is possible and quite probable that the death rate is high just after the breeding season, but there is nothing to indicate that all the fish die after spawning. The dead and dying examples bore no evident scars.

Diligent inquiry brought forth no account of the species spawning in the lakes. No one was found who had even seen one there. Hours of observation from tufa domes failed to detect any among the myriads of fishes which could be easily identified. Yet on May 11, 1913, large numbers of "cui-ui" were found depositing eggs along the shallows near some springs on the southwest shore. Both ripe males and females were examined. The Indians were after them almost immediately, and they declared that these were the first that they had seen in the lake. None was observed here May 16 or later. A few individuals were found spawning in Winnemucca Slough.

During the breeding season the males differ from the females in color and there is some variation in both sexes. The males have a dense black stripe 5 to 6 scales wide extending 10 scales below the dorsal fin from the opercle to the base of the caudal. The borders are interrupted here and there by brassy or silvery scales. Above the black stripe are numerous reddish-bronze scales with dark spots. The middle of the back is dusky, and this dark surface, together with the black stripe below, causes the red area to stand out boldly, especially when the fish turning in the water flashes the metallic red in the sunshine. Below the black stripe the body is silvery, many scales having a brassy sheen. The ventral surface is clean, dead white. The upper part of the head is blackish, the lower part whitish. The fins are slate blue, the paired ones lighter than the others. The tubercles are yellowish white. When the fishes are observed in the water from directly overhead, the stripes are very prominent, converging posteriorly and meeting over the caudal peduncle. The head appears lighter than the body, and the fins are very distinct. Some individuals are much duller, but in every specimen there is at least a strong trace of the red and dark stripes.

In the female the whole upper surface is dark brownish-black, not the olive color usually seen in suckers. The sides are brassy, often more or less dull, and frequently the darker color is broken up into clouds on the sides. Occasionally the entire dorsal region of a female is tinged with a reddish coppery hue, the edges of the scales having a decided metallic luster. Sometimes the females are called black suckers. At times whole schools of both sexes were seen, apparently ready to spawn, but without a single individual with fully developed colors.

Some Indians assert that they can distinguish between "cui-ui" from the different lakes. Those from Winnemucca, said to be lighter in color and inclined to be spotted, are known as Izhi-"cui-ui." The writer after examining many specimens from both lakes was unable to detect any difference.

Observers differ somewhat as to the most distant point reached by *C. cujus* during the nuptial migration. It appears in large numbers at the great bend of the Truckee, and it certainly ascends the river somewhat beyond the confines of the ancient Lake Lahontan. It never quite approaches the swift water above Reno. It would no doubt be a physical impossibility for the species to stem the turbulent water of the river canyon. The great blunt head and huge body, loaded down with eggs and fat, and the relatively small and weak caudal fin are not calculated to lend speed or endurance to a fish entering the current of a river for perhaps the first time. If Pyramid and Winnemucca Lakes contract and become too salty for fresh-water species, as may possibly transpire if much water is withdrawn from the Truckee River for irrigation purposes, this species no doubt will disappear.

Spawning appears to be more active at night than in the daytime, and so, also, is migration. This became evident from direct observation and from the fact that early morning usually revealed greatly changed conditions in the river population.

At times "cui-ui" appeared in such large and densely packed schools that considerable numbers were crowded out of the water in shallow places, especially on the gently sloping river bars. Once several hundred were observed stranded near the mouth of the river. In some places they were jammed together in masses two or three deep. Some were crowded entirely out and dead, while others were in water a foot deep, yet pushing close to the main group in a perfectly demoralized condition. When one such conditionally free individual was carried some distance away and headed upstream, it passed on its way with great speed, but if removed a short distance only it returned to the mass like an iron to the magnet. It was impossible to separate any number and get them started away from the stranded school. Cormorants, gulls, and pelicans in great numbers were attacking them, and many of the still wriggling fishes had lost their eyes and strips of flesh had been torn from their sides.

The stomachs of all specimens examined were devoid of food.

The largest specimen seen measured 670 millimeters, the smallest 410.

Males.		Females.	
Length.	Weight.	Length.	Weight.
Inches.	*Pounds.*	*Inches.*	*Pounds.*
20.5	3	24.75	6
17.25	2	23.5	5.25
19.75	3	20.5	3.5
19.25	3	21.25	4
21.25	3.5	21.75	4.75
20	3.25	22.5	5
		20.75	3.75

The flesh of this species is highly prized by the Indians. In former times the coming of the "cui-ui" was a great event, not only for the Pyramid Lake tribe but also for other Piutes from far to the south, who sometimes reached the fishing grounds in such a starved condition that many were unable to survive the first feast. At present numerous little camps may be seen along the river during the spawning period. The fishes are caught in large numbers and tons of them are dried for later use. They are taken most easily when the river is roily, the fishermen hooking them with an improvised gaff which is drawn quickly through the muddy water. Knowing the "cui-ui" habit of resting in schools in quiet water, the Indian establishes his camp accordingly, and the willows, wire fence, or hastily constructed rack are soon covered with unsalted drying fish, which attract numbers of flies and send characteristic odors a long distance down the wind.

When properly cooked, the flesh is sweet and palatable, equal to that of some fishes which bring a fair price in the city markets. The uncleanly methods of preservation employed by the Indians have caused the "cui-ui" to be regarded with prejudice, and white people of the region will not eat them.

A male specimen measuring 600 millimeters in length is here described, and measurements of others follow:

Head, 3.7 in length to base of caudal; depth, 4.3; depth caudal peduncle, 3.5 in head; snout, 2.2; eye, 10.5; width mouth, 3; interorbital space, 2.3; height dorsal, 2.3; anal, 1.4; length pectoral, 1.5; ventral, 2; caudal, 1.4.

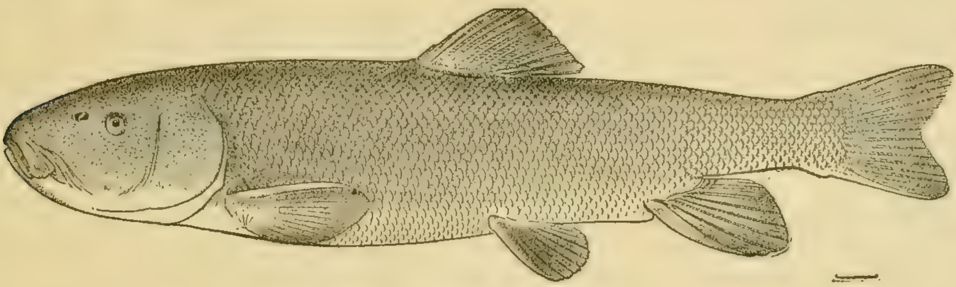

FIG. 2.—*Chasmistes cujus*. "Cui-ui."

Head and body extremely robust, broad, and round; top of head broad and slightly convex; cheeks puffed out; eye small when compared with the great size of head; snout projecting beyond mouth, evenly rounded in life, the premaxillary process presenting no "hump," the latter being characteristic of poorly preserved or dried specimens; lips smooth, the lower broad and pendulous; both lips plainly show traces of papillæ, which appear as if once developed but since united and grown over. Posterior margin of opercle broadly and evenly rounded, the free fleshy edge about equal in width to half the diameter of eye. There are 43 gillrakers on the first arch. All have wide, papillose edges, the lower ones being especially broad and brushlike, the upper ones falcate and comparatively narrow. The digestive tract is long and coiled many times. The testes are of huge dimensions and lobular. The air bladder extends to a point above posterior edge of base of ventrals. Peritoneum dusky, almost black. The skin of the head is smooth, the dorsal surface with many minute tubercles. Body completely scaled, the scales large and even, nowhere densely crowded. Each scale, excepting those on the ventral surface and immediately above and behind the pectorals, with a tubercle at its tip. Rays of fins with tubercles; those on pectorals, ventrals, and dorsal small; on anal large and sharply pointed.

Base of second dorsal ray inserted half way between tip of snout and posterior edge of last caudal vertebra. Ventrals below posterior half of dorsal; pectorals broadly rounded; anal obtusely pointed; caudal concave.

The females are more stocky than the males, and with their huge heads, large rounded bodies, and relatively short fins are very ungainly looking fish. The scales and fins are without tubercles.

Species related to *Chasmistes cujus* are found in the Bonneville and Klamath Lake Basins.

MEASUREMENTS OF CHASMISTES CUJUS, TRUCKEE RIVER, NEAR MOUTH.

Length of body..........mm..	444	410	416	420	410	412	418	492	437
	♂	♂	♂	♂	♂	♂	♂	♂	♂
Length head	0.28	0.27	0.285	0.275	0.30	0.29	0.28	0.275	0.275
Depth body	.22	.22	.21	.225	.21	.22	.22	.185	.19
Depth caudal peduncle	.09	.09	.09	.085	.083	.09	.085	.075	.08
Length caudal peduncle	.15	.145	.15	.15	.16	.18	.162	.16	.15
Length snout	.13	.13	.13	.13	.142	.135	.125	.125	.12
Diameter eye	.03	.027	.03	.035	.03	.035	.03	.03	.03
Interorbital width	.13	.12	.13	.12	.13	.13	.125	.115	.12
Depth head	.185	.18	.19	.185	.19	.195	.20	.176	.185
Snout to occiput	.23	.22	.23	.22	.23	.23	.23	.21	.215
Snout to dorsal	.52	.50	.515	.50	.52	.545	.52	.495	.51
Snout to ventral	.57	.57	.57	.58	.63	.605	.59	.57	.57
Length base of dorsal	.155	.135	.15	.15	.165	.165	.14	.155	.15
Length base of anal	.085	.09	.10	.095	.10	.10	.09	.09	.10
Height dorsal	.14	.14	.13	.125	.14	.14	.12	.12	.125
Height anal	.20	.20	.19	.18	.20	.225	.205	.195	.195
Length pectoral	.205	.19	.185	.185	.20	.20	.18	.175	.185
Length ventral	.155	.135	.13	.13	.15	.145	.125	.135	.14
Length caudal	.21	.21	.21	.20	.205	.205	.215	.185	.195
Dorsal rays	11	10	11	11	12	11	11	12	11
Anal rays	7	7	7	7	8	7	7	7	8
Scales lateral line	60	60	64	62	66	64	62	61	61
Scales above lateral line	13	13	14	13	14	14	13	13	14
Scales below lateral line	10	10	11	10	12	10	10	10	10
Scales before dorsal	29	30	32	32	31	33	31	35	33

Length of body..........mm..	422	417	538	525	485	515	451	445	452
	♂	♂	♀	♀	♀	♀	♀	♀	♀
Length head	0.27	0.275	0.275	0.27	0.285	0.275	0.285	0.275	0.28
Depth body	.215	.20	.225	.22	.24	.215	.22	.22	.225
Depth caudal peduncle	.085	.08	.08	.08	.082	.08	.085	.085	.085
Length caudal peduncle	.165	.165	.162	.155	.145	.14	.155	.155	.155
Length snout	.12	.13	.125	.13	.14	.14	.13	.13	.132
Diameter eye	.03	.03	.034	.025	.029	.028	.03	.03	.03
Interorbital width	.125	.12	.125	.125	.13	.125	.125	.125	.12
Depth head	.195	.18	.185	.19	.195	.185	.19	.175	.18
Snout to occiput	.225	.215	.21	.225	.225	.225	.22	.215	.22
Snout to dorsal	.51	.505	.51	.505	.50	.515	.505	.493	.51
Snout to ventral	.57	.57	.58	.60	.575	.57	.595	.59	.58
Length base of dorsal	.14	.15	.125	.133	.145	.125	.135	.14	.13
Length base of anal	.09	.09	.09	.073	.075	.08	.08	.09	.08
Height dorsal	.12	.12	.11	.12	.13	.13	.125	.132	.125
Height anal	.19	.21	.145	.15	.15	.16	.16	.174	.155
Length pectoral	.19	.18	.175	.18	.165	.18	.18	.18	.165
Length ventral	.13	.14	.11	.12	.115	.12	.115	.125	.11
Length caudal	.21	.20	.185	.18	.17	.175	.19	.20	.185
Dorsal rays	11	11	10	11	11	10	11	11	11
Anal rays	7	7	7	7	7	7	7	7	7
Scales lateral line	64	59	62	64	59	62	61	62	61
Scales above lateral line	14	14	14	14	14	14	14	13	14
Scales below lateral line	10	11	11	10	10	10	10	10	10
Scales before dorsal	32	30	33	29	31	31	29	31	28

Richardsonius egregius (Girard). Red-striped shiner.

This beautiful little fish is almost universally distributed throughout the brooks, rivers, and lakes of the region.[a] It is found not only in the lower courses of the rivers where the water is deep and quiet, but it also stems the swift currents of the high mountain tributaries, following closely in the wake of the smallest trout. It is best known as a river species—the bait fish of the angler, the "minny" of the small boy, and the food of the kingfisher and tern. It delights in the slow ripples and the quiet, shallow pools, where large numbers may be seen swimming lazily about over the submerged bars, occasionally turning their silvery sides to the bright sun. In the lakes it congregates in large schools, swimming about submerged logs, tops of fallen trees, wharves, and other sheltered places.

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[a] *R. egregius* has been reported from two localities in the Sacramento Valley (Bulletin, United States Bureau Fisheries, vol. XXVII, p. 135). On direct comparison with examples from the Truckee Basin, the specimens upon which this report was based, including the type of *Phoxinus clevelandi*, were found to differ in no respect from typical individuals of *R. egregius*. The writer has at different times attempted to secure specimens of this species from the Putah Basin, including Aetna Springs Creek, the supposed type locality of *P. clevelandi*, but without success, and it seemed safe to conclude that it is not a native of that basin. Now, Rutter's discovery of the species in a tributary of Feather River reopens the question. In this connection, however, it will be recalled that *Agosia robusta*, *Pantosteus lahontan*, and *Catostomus tahoensis* were also reported by the same author from a tributary of the Feather River. Since neither of these four forms has been seen elsewhere in the Sacramento River, excepting possibly *R. egregius* as *P. clevelandi*, the suggestion is offered that either these species have been recently introduced along with trout from the Truckee Basin or that Rutter was lead into an erroneous statement from a confusion of labels.

The relationships of the species appear to be with *R. balteatus* and *R. hydrophlox*, in some characters approaching the latter more closely. It may not be out of place to remark, however, that speculation regarding this and other western species of the genus will remain more or less futile until something more definite is known of the fauna of the upper Columbia and the Bonneville Basins.

In describing this species Girard[a] gives the locality as unknown. The register in the National Museum records Humboldt River, the entry having been made in February, 1857. The type is in all respects like specimens of the species from the Humboldt and other rivers of the Lahontan system.

This is one of the most brilliantly colored fishes of the West, not even excepting the trout. The brightest hues appear for a short time only during the breeding season and are seen at their best in the males.

While examining Fallen Leaf Creek, a tributary of Lake Tahoe, on June 10, large schools of this species were observed making their way up the smaller tributaries, progressing chiefly at night, when they might be seen or heard struggling over the small rapids and leaping the miniature falls. Both sexes were highly colored, the males especially so, where small whitish epidermal nodules appear on the surface of the head, on the opercles, throat, and body, each scale along the sides having from one to three on its posterior edge. Later observation indicated that these fishes were at that time rapidly attaining the most advanced stages in their brilliant nuptial color.

Specimens were collected from day to day and the changes in color noted. Many ripe males were found at the time, but only an occasional ripe female. One of the latter was a deep olive green above, lighter on the sides, and silvery beneath, brassy and silvery metallic reflections appearing on various parts of the head and body. A distinct brassy stripe extended from the posterior border of the eye, across the upper edge of the opercle, straight along the side of the body and upper third of the caudal peduncle. Below the lateral line was a broad, indistinct area of violet pink over a brassy ground, the latter becoming more intense ventrally. Belly silvery, a narrow, bright-red axillary dash present. Iris tinted with pink. The females mostly were duller at first, many being seen with but a trace of the metallic or red color. A ripe male was deep olive green above, lighter on the sides, and whitish beneath. When viewed from the side or from below, silvery and brassy reflections appeared, these being suffused with a tint of violet pink, an occasional scale or group of scales remaining dark in any light. Two rather distinct brassy stripes extended from snout to caudal, one beginning at upper anterior edge of eye, crossing upper edge of gill opening, and extending posteriorly to upper third of caudal peduncle, the other, less definite in outline, passing from corner of mouth across preopercle, where it broadened and became brilliantly iridescent, along head and body above base of pectoral and straight back to caudal. Posteriorly the lower stripe became somewhat indistinct, but as the fish turned it flashed brighter in the sunlight. Below the lower stripe the sides were strongly suffused with pink, the suffusion growing more intense and darker in tone toward the axil of pectoral where it was light blood red, a dash of brilliantly burnished brass extending forward on base of pectoral to a point below the edge of preopercle. The fins were yellowish orange with metallic reflections, and likewise the body at bases of ventrals and anal.

Other males were much subdued in color, some possessing scarcely a bright tint. As time passed the color of even the brightest rapidly increased in intensity, the brassy reflections becoming more highly burnished, a broad, blood-red band appearing above the base of the pectorals and extending to the origin of the anal, the posterior part being yellowish and broken into spots. The abdomen became dead white. The most brilliantly colored males had a narrow red stripe below the eye, and the lateral dusky stripe that is present in all and which persists in preserved specimens was deep black. When placed in alcohol, the color soon became brighter on all parts of the body, and even appeared in specimens where none was seen in life. In preserved specimens the bright tints soon pass away, leaving the body with a pale, silvery sheen, very dark above, with a broad black lateral stripe, above which is a narrow yellowish stripe, and below which the sides are covered with spots more or less definitely arranged in stripes.[a]

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[a] Pacific Railroad Survey, X, 1858, p. 291.

During the nuptial migration of *Catostomus*, before noted, large numbers of this species followed the female suckers, feeding on the eggs. Many eggs were found in the stomachs of the minnows. Neither male nor female spawning suckers objected to the presence of the minnows, the latter swarming about and at times darting over and under them.

Many examples were caught with hook and line in Lake Tahoe. None of these exhibited bright colors, although taken at the time when others of the species were spawning in the streams near by. On dissection the ovaries of some of these were found to contain large eggs, although in most cases they were immature. Females here far outnumbered the males.

On May 14 specimens in nuptial colors and nearly ripe eggs were secured in the Truckee River near Pyramid Lake. Examples taken at the same place April 24 had only traces of red color. Specimens from the Humboldt River collected after July 1 had spawned. These were generally lighter in color than those of the Tahoe region, as were also examples from Carson and Walker Rivers.

A few specimens taken August 11 in Walker River near the outlet contained large numbers of almost fully developed eggs. Some rather brightly colored males were found there at the same time.

The teeth of 20 specimens were examined, and in general they numbered 2–4 on the right side, 2–5 on the left. Variations of 1–4 and 1–5 were observed, and in one example an extra row of 2 teeth appeared on one side, making 3 rows in all. The teeth of the outer row are strongly hooked, and when a grinding surface appears it is very narrow and indistinct. The alimentary canal is S-shaped and very short. The gillrakers number 8 or 9, occasionally 7; of these, 5 or 6 are on the lower arch. They are very short and for the most part sharply pointed. The peritoneum is silvery, immaculate on the belly, generally covered with blackish spots on the sides and above. The spots are more numerous and the effect darker in specimens from the mountain streams, while in examples from the sandy rivers of the desert they are less numerous and the color effect decidedly lighter. Individuals show much variation in the size, shape, and number of pigment spots. The edges of the dorsal and anal are straight or slightly concave. The caudal is large and deeply cleft, especially in male examples.

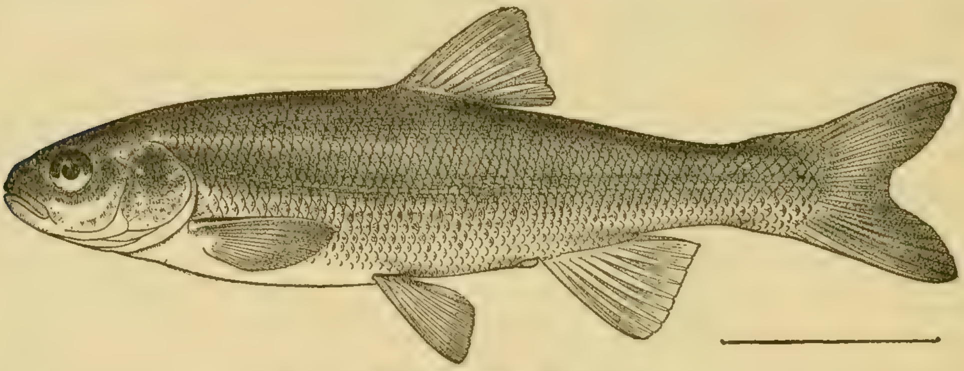

FIG. 3.—*Richardsonius egregius.* Red-striped shiner.

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[a] *Richardsonius balteatus* is a species which exhibits a range and variety of coloration similar to that of *R. egregius*, and seemingly a lack of appreciation of this is what led Evermann and Cockerell (Proceedings, Biolographical Society, Washington, XXII, 1909, p. 185) to the conclusion that examples of *R. balteatus* from Warm Springs, Oreg., represented a new form which they name *R. thermophilus*.

The warm springs from which the locality gets its name flow into a marsh, where water of an even temperature is maintained throughout the year. Silver Creek drains this marsh. The water is full of algæ and at times swarms with minute crustacea and the larvæ of insects. Many large, well-fed, fat fishes collected here belonged to three genera of minnows, and they were much alike in color and form, differing in the same way from other specimens of like species taken at various places in Silver Creek, just as trout from a deep, shaded pool differ from those living in a shallow, sandy stream. The specimens of *R. balteatus* found here and in other parts of Silver Creek possess certain characteristics of a local nature, as do other examples of the species from particular parts of its very wide range, but although attempts have been made to coordinate these local variations with reasonable geographic distribution no success has been achieved.

The description of *R. thermophilus* mentions no distinctive characters and contains nothing more than had been previously published regarding the specimens upon which the species is based, save a figure of an enlarged scale. This differs in no way from others of *L. balteatus* from various places in the Columbia Basin.

Females are larger than males, their bodies are more robust, and their fins are lower and shorter. The largest individuals seen measured 5½ inches.

The food seems to consist mostly of aquatic larvæ and winged insects. No algæ or other vegetable matter was found in the stomachs, except such as might have been swallowed by accident.

The scales are very regular in size over the entire body; small, deeply embedded, and scarcely evident on the breast. There are from 52 to 61 in the lateral line, 54 to 59 being the usual number. The following tables give the scale rows and fin rays in a number of examples:

	Scales in lateral line.										Scales above lateral line.		
Number of scales	52	53	54	55	56	57	58	59	60	61	12	13	14
Number of specimens	2	8	16	20	16	22	20	16	11	3	21	48	20

	Rays in dorsal fin.			Rays in anal fin.		
Number of rays	7	8	9	8	9	10
Number of specimens	5	82	1	34	43	5

Careful measurements and a direct comparison of specimens reveal no characters peculiar to any particular isolated basin.

Measurements of 20 specimens follow.

MEASUREMENTS OF RICHARDSONIUS EGREGIUS.

FALLEN LEAF CREEK, NEAR LAKE TAHOE.

Length of body . . . mm.	77	86	80	75	81	90	90	85	85	81
	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀
Length head	0.25	0.24	0.26	0.25	0.24	0.24	0.24	0.25	0.24	0.25
Depth body	.23	.24	.25	.22	.23	.25	.26	.25	.24	.24
Depth caudal peduncle	.10	.10	.115	.10	.105	.10	.095	.10	.10	.10
Length caudal peduncle	.235	.23	.21	.24	.23	.21	.22	.24	.24	.21
Length snout	.075	.075	.075	.075	.075	.065	.07	.06	.065	.075
Diameter eye	.06	.06	.07	.06	.06	.055	.06	.055	.06	.06
Interorbital width	.075	.08	.10	.08	.08	.085	.08	.08	.08	.09
Depth head	.19	.17	.19	.18	.18	.18	.17	.18	.18	.17
Snout to occiput	.21	.19	.21	.20	.20	.185	.19	.19	.19	.19
Snout to dorsal	.535	.53	.55	.55	.52	.55	.55	.56	.54	.54
Snout to ventral	.48	.48	.52	.48	.47	.50	.49	.48	.51	.49
Length base of dorsal	.13	.105	.12	.10	.12	.105	.11	.10	.115	.125
Length base of anal	.12	.125	.12	.105	.13	.12	.11	.125	.115	.11
Height dorsal	.21	.19	.21	.19	.195	.195	.17	.19	.20	.18
Height anal	.19	.18	.19	.19	.18	.18	.175	.165	.18	.17
Length pectoral	.23	.21	.24	.23	.21	.18	.185	.19	.18	.19
Length ventral	.185	.155	.19	.17	.16	.15	.15	.16	.14	.15
Length caudal	.27	.25	.29	.25	.255	.24	.235	.25	.245	.24
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	8	9	8	8	9	9	8	9	8	8
Scales lateral line	54	60	54	55	56	54	59	59	56	59
Scales above lateral line	12	12	12	13	12	12	13	12	13	13
Scales below lateral line	6	6	6	6	6	7	7	7	6	6
Scales before dorsal	27	30	29	31	30	30	31	31	31	31

MEASUREMENTS OF RICHARDSONIUS EGREGIUS—Continued.

STAR CREEK, NEAR DEETH, NEV.

Length of body..........mm..	84	73	76	74	70	100	100	96	91	82
	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀
Length head	0.25	0.25	0.25	0.26	0.25	0.24	0.24	0.24	0.25	0.26
Depth body	.24	.25	.26	.265	.25	.26	.26	.24	.28	.27
Depth caudal peduncle	.105	.10	.11	.10	.10	.10	.095	.10	.10	.11
Length caudal peduncle	.22	.21	.23	.23	.23	.22	.22	.21	.21	.22
Length snout	.07	.07	.07	.075	.07	.07	.07	.065	.07	.075
Diameter eye	.055	.06	.06	.065	.06	.055	.06	.06	.06	.065
Interorbital width	.09	.09	.08	.085	.08	.08	.085	.08	.08	.09
Depth head	.19	.19	.18	.18	.18	.18	.18	.17	.19	.18
Snout to occiput	.19	.20	.20	.185	.20	.18	.19	.18	.19	.20
Snout to dorsal	.55	.565	.55	.53	.55	.57	.55	.55	.56	.55
Snout to ventral	.51	.50	.49	.49	.51	.49	.50	.49	.51	.51
Length base of dorsal	.11	.10	.11	.12	.10	.11	.115	.11	.10	.10
Length base of anal	.12	.11	.11	.12	.12	.12	.11	.125	.11	.125
Height dorsal	.19	.19	.20	.20	.21	.18	.19	.18	.20	.19
Height anal	.17	.18	.18	.19	.20	.18	.17	.17	.19	.18
Length pectoral	.21	.22	.22	.23	.22	.18	.19	.17	.18	.20
Length ventral	.16	.16	.17	.16	.16	.15	.16	.145	.16	.15
Length caudal	.26	.26	.265	.25	.26	.23	.24	.21	.24	.24
Dorsal rays	8	8	8	8	8	8	8	8	7	8
Anal rays	9	8	8	9	9	9	9	9	8	8
Scales lateral line	58	55	55	57	57	56	54	53	54	55
Scales above lateral line	14	13	13	13	13	13	12	12	14	13
Scales below lateral line	6	6	6	7	7	7	6	6	7	7
Scales before dorsal	33	32	30	31	31	31	31	30	32	33

Cockerel and Allison[a] employ structural scale characters to distinguish between this and other species of the genus. Their conclusions, apparently based on few specimens, will not stand the test of this species, for the scale radii are found to number from 6 to 21 and the number of circuli depends upon the age of the individual from which the scale was taken. The variable character of the peritoneum pigment has been described. The annexed table will exhibit the number of radii possessed by a few scales taken from between the lateral line and dorsal fin of specimens of *R. egregius* selected at random from several localities.

Number of radii	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21
Number of specimens from—															
Walker River	....	....	....	2	6	1	7	1	3	....	2	....	....	....	....
Truckee River	....	....	4	8	5	6	2	3	....	....	....	....	....	....	....
Susan Creek	....	1	2	2	1	4	12	9	3	2	16	....	....	....	....
Star Creek	....	....	6	11	20	21	12	9	7	....	....	....	....	....	....
Quinn River	1	1	9	9	17	14	7	6	4	1	1	....	....	....	....
Fallen Leaf Lake	....	....	1	....	2	3	9	4	6	11	3	2	3	1	1
Carson River	1	9	10	13	4	1	10	9	3	4	2	1	1	....	....

Richardsonius microdon, new species. Tahoe shiner.

This species will not be confused with *Richardsonius egregius*, another member of the genus found in the basin, for it has a much more robust form, a heavier caudal peduncle, a longer snout, and a larger mouth. In general appearance it more closely resembles *Siphateles obesus* and *Leucidius pectinifer*, having the same general color and shape, except that the body is a little more slender, the head somewhat longer, the snout more pointed, the mouth larger, and the posterior border of the opercle more angular. From these it may be told at a glance by the posterior position of its dorsal fin. The species is not distinguished from either *S. obesus* or *L. pectinifer* by the local fishermen, but it is not mistaken for *R. egregius*.

Description of type, No. 75652 United States National Museum, a female measuring 140 mm., from Lake Tahoe, near Tahoe City, Cal., June 27, 1911:

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[a] Proceedings, Biological Society, Washington, vol. XXII, p. 160.

Radii few (8 or 9); lateral circuli about 30 on each side; peritoneum silvery, nearly as in *neogaeus*, but with more diffuse, large brownish spots. Willow Creek, Honey Lake Basin, Cal. *L. egregius* (Girard).

Radii more numerous (10 to 13); peritoneum silver, with black spots on upper part. Eagle Lakes, Me. *L. neogaeus* (Cope).

Radii most numerous (15 to 20); but only about 10 complete; circuli about 20 on each side; peritoneum silver, with many spots, mostly reddish brown, some black, none large, the general effect not dark, though the spots are numerous. Cemetery. Creek, Watertown, N. Y. *L. margarita* (Cope).

Head 3.75 in length to base of caudal; depth 3.75; depth caudal peduncle 10; snout 3.5 in head; eye 4.5; interorbital space 3; height dorsal 1.4; anal 1.7; length pectoral 1.3; ventral 1.7; caudal 1; scales lateral series 53; dorsal rays 8; anal 8.

The general shape is much like that of the young of *S. obesus*, the head being longer and more pointed, the mouth a little less oblique, the eye slightly larger, the opercle more angular, and the caudal peduncle more slender. Width of body somewhat less than half the depth. Diameter of eye less than length of snout; interorbital space convex; cleft of mouth not quite reaching a vertical through anterior edge of orbit. Gillrakers 13, slender, sharply pointed and curved downward; the largest about equal in length to vertical width of posterior nostril; space between gillrakers about equal to width of base of gillraker. Teeth 1, 5-5, 1; hooked, with a narrow grinding surface; the teeth of inner row very frail. Lateral line complete, strongly decurved on anterior third of body. Body completely covered with large scales, which are nowhere much reduced in size nor crowded. Dorsal inserted well behind a vertical through origin of ventrals; edge of anal straight; caudal deeply cleft, the lobes pointed; edges of ventrals rounded, the depressed fin just reaching the anal opening; pectorals obtusely pointed.

Color in spirits dark above and light below, as usual in minnows, the dusky pigment spots clustering along the edges of the scales. A rather indefinite lateral stripe extends along the side, becoming more definite posteriorly, where it is about 3 scales wide, and ending just anterior to base of caudal fin in an enlarged, rounded spot. In life the upper parts were olive, the sides somewhat silvery. The peritoneum is silvery but thickly dusted with black pigment. The alimentary canal is not quite equal in length to the total length of the specimen.

The teeth of the inner row are very frail and seem to be on the verge of disappearing entirely. Three specimens, in addition to the type, have them as follows: 1, 5-5, 1; 1, 4-5, 0; 0, 5-5, 1.

Only four examples of this species have been seen. They were taken with baited hook from below the wharf at Tahoe City. All were females, the eggs being well developed and relatively few in number. Measurements of these specimens follow:

MEASUREMENTS OF RICHARDSONIUS MICRODON.

Length of body.....mm..	123	110	102	90	Length of body......mm..	123	110	102	90
Length head	0.26	0.27	0.28	0.29	Height dorsal	0.17	0.20	0.20	0.19
Depth body	.25	.26	.25	.255	Height anal	.15	.16	.18	.17
Depth caudal peduncle	.10	.10	.11	.115	Length pectoral	.19	.21	.21	.20
Length caudal peduncle	.22	.21	.20	.22	Length ventral	.15	.16	.18	.15
Length snout	.075	.075	.075	.08	Length caudal	.25	.27	.28	.26
Diameter eye	.05	.06	.06	.06					
Interorbital width	.09	.085	.09	.09	Dorsal rays	8	8	8	8
Depth head	.17	.18	.185	.19	Anal rays	8	9	8	8
Snout to occiput	.19	.19	.20	.22	Scales lateral line	53	55	53	56
Snout to dorsal	.53	.53	.54	.55	Scales above lateral line	12	11	11	12
Snout to ventral	.50	.51	.52	.53	Scales below lateral line	6	6	6	6
Length base of dorsal	.12	.13	.12	.13	Scales before dorsal	27	28	28	28
Length base of anal	.11	.12	.12	.12					

The writer is inclined to regard this species as a possible representative of *R. caurinus*[a] of the Columbia. They are not very unlike in general appearance, although the Columbia species is more slender, suggesting *Ptychocheilus* in shape. The dorsal fin in each is inserted posterior to a vertical through bases of ventrals. Its relationships may be with *R. bicolor* of the Klamath. It is probably not closely related to *R. atrarius*[b] of the Bonneville Basin.

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[a] A specimen of *Richardsonius caurinus* was lately found by the writer in the National Museum collection. It is the second recorded since the species was described by Richardson. It was collected by Livingston Stone, but nothing further is known of it. It measures 9½ inches in length. There are 79 scales in the lateral line, about 20 between lateral line and back. Dorsal 10; anal 9. The pectorals are rather sharply pointed. The edge of the anal is slightly concave.

[b] It is believed that the name *Richardsonius atrarius* (Girard) should stand for the species recognized by recent authors as *Leuciscus lineatus* (Girard). (Bull., No. 47, United States National Museum, 1896, p. 232.) The type of *Tigoma lineata* Girard is lost, and the locality from which it was obtained is unknown. Furthermore, it was described (Proceedings, Academy Natural Sciences, Philadelphia, 1856, p. 206.) as being "elongated, the body subfusiform, the head small and conical," a form apparently like that of *R. balteatus*, *R. hydrophlox*, or *R. egregius*. Also, the describer remarks of his *Tigoma egregia*, "By its general aspect this species resembles *T. lineata*." *Siboma atraria* Girard (Proceedings, Academy Natural Sciences, Philadelphia, 1856, p. 208) on the other hand is a deep-bodied, thick-tailed form with a comparatively large head, not to be compared with *R. egregius* (*Tigoma egregia*), which is elongated, subfusiform, trim, and graceful.

The type of *S. atraria*, United States National Museum, no. 236, is a specimen somewhat over 6 inches long. There are 9 rays in the dorsal fin, 8 in the anal; 56 scales in the lateral series; 12 between lateral line and back; 30 between occiput and

Siphateles obesus (Girard). Lake chub. (Species illustrated on p. 64.)

This is the *Rutilus* or *Myloleucus*[a] *olivaceus* of recent authors, which, at times confused with *Leucidius pectinifer*, has been reported from various parts of the Lahontan system. It was first described from the Humboldt River as *Algansea obesa*.[b] The type of this species, no. 193, United States National Museum, is a specimen measuring 171 millimeters, and although the pharyngeal bones have been removed there seems to be no reason to doubt that it belongs to the same species which Cope later called *Leucus olivaceus*, and which is abundantly represented in the Humboldt River, its tributaries, and other streams and lakes of this system.

S. obesus is related to similar forms, *S. columbianus*, *S. formosus*,[c] *S. bicolor*, and *S. oregonensis*, of the Columbia, Sacramento, Klamath, and Oregon Lake systems. Its affinities are most close to the Oregon Lake form, *S. oregonensis*, and it is very doubtful whether the latter should be recognized at all. The form called *S. oregonensis* is made up of isolated units which occupy distinct basins and which

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dorsal fin. The following measurements are in hundredths of the length to base of caudal fin, which is 130 millimeters. Head 0.28; depth body 0.28; depth caudal peduncle 0.11; snout to occiput 0.22; snout to dorsal 0.54; snout to ventral 0.56. The gillrakers are 11 in number, short and pointed.

R. atrarius and *Tigoma obesa* Girard (Proceedings, Academy Natural Sciences Philadelphia, 1856, p. 206) are apparently not synonymous. The type of the latter, United States National Museum, no. 215, is a specimen with a very long deep body, small head, and short rounded fins, looking much like a well-fed and fat example of *R. balteatus*, such as one occasionally finds in a slough or pond where food is very abundant. Its describer says that it came from Salt Lake Valley. The Museum register gives no locality. The teeth, 5, 2–2, 4, have a narrow grinding surface. There are 8 rays in the dorsal, 9 in the anal; scales in the lateral series 55; between lateral line and back 13; between occiput and dorsal fin 28. Length from snout to base of caudal 111 millimeters; length head 0.25; depth body 0.24; depth caudal peduncle 0.11; snout to occiput 0.19; snout to dorsal 0.59; snout to ventral 0.55. There are 7 stubby, pointed gillrakers. If this specimen was collected in Salt Lake Basin, it apparently represents a species not since found there.

Richardsonius humboldti (Girard) is another nominal form known from the type only (Proceedings, Academy Natural Sciences Philadelphia, 1856, p. 206). It is said to have been collected by Bowman and Beckwith in the Humboldt River. The species has not been seen there since. There is difficulty in distinguishing between the type specimen and examples of *R. hydrophlox*. It has a somewhat larger head, deeper body, and deeper caudal peduncle than any specimen of *R. hydrophlox* with which it has been compared. It differs from examples of *R. egregius* from the Humboldt in having 11 rays in the anal fin, a deeper body, larger head, and larger eyes. There are 54 scales in the lateral series, 13 between the lateral line and back, 29 between occiput and dorsal fin. The dorsal is inserted considerably behind a vertical through the ventrals. Both this specimen and the type of *T. obesa* were collected in the course of one of the early surveys. Neither has had an attached label. Both look like over-fed examples of the same species which might have lived in a spring or pond, the bloated body and short, rounded fins being characteristic.

[a] Fowler (Proceedings, Academy Natural Science, Philadelphia, 1913, p. 71) finds that the cotype of *Myloleucus pulverulentus* Cope which is preserved in the collection of the Philadelphia Academy has 2 rows of pharyngeal teeth. No type or cotype of the species is in the National Museum. The specimen examined by Fowler is apparently a *Richardsonius*. The name *Siphateles* (Cope, Proceedings, Academy Natural Science, Philadelphia, 1883, p. 146) then becomes available for the lake and channel species that have been referred to *Rutilus* and *Myloleucus*. Through the kindness of Mr. Fowler the writer was enabled to examine the type of *Siphateles vittatus* Cope at the museum of the Philadelphia Academy. It is a specimen belonging to the species that is here called *S. obesus*.

[b] Girard, Proceedings, Academy Natural Science, Philadelphia, 1856, p. 183.

[c] On careful comparison, the type of *Algansea formosa* Girard from Merced River, Cal., and also a number of specimens from Wolf Creek, north fork of Feather River, collected by Rutter and referred to *Rutilus bicolor*, are found to differ in no way from examples taken in Pit River and Goose Lake, these in turn being like those described by Cope as *Myloleucus thalassinus*. *Siphateles* (*Rutilus* or *Myloleucus*) *bicolor* is confined to the Klamath Basin and should not be confused with the Sacramento form. The latter will now be referred to as *Siphateles formosus*. A partial synonomy of these forms may serve to eliminate some of the confusion regarding them:

Siphateles formosus (Girard).—Sacramento-San Joaquin system, including Goose Lake and its tributaries. *Algansea formosa* Girard, Proceedings, Academy Natural Sciences, Philadelphia, 1856, p. 183. *Myloleucus thalassinus* Cope, Proceedings, Academy Natural Sciences, Philadelphia, 1883, p. 144. *Rutilus symmetricus* Jordan and Evermann, Bulletin 47, United States National Museum, 1896, p. 245. *Rutilus thalassinus* Snyder, Bulletin, Bureau Fisheries, vol. xxvii, 1907, p. 86. *Rutilus bicolor* Rutter, Bulletin, Bureau Fisheries, vol. xxvii, 1907, p. 135.

Siphateles bicolor (Girard).—Klamath River, Klamath Lake, and tributaries. *Algansea bicolor* Girard, Proceedings, Academy Natural Sciences, Philadelphia, 1856, p. 183. *Myloleucus parovanus* Cope, Proceedings, Academy Natural Sciences, Philadelphia, 1883, p. 143. *Rutilus bicolor* Jordan and Evermann, Bulletin 47, United States National Museum, 1896, p. 244. Gilbert, Bulletin, United States Fish Commission, vol. xvii, p. 8, figure.

Siphateles oregonensis (Snyder).—Lake region of southeastern Oregon; generally distributed. (Not in Goose, Klamath, and Malheur Basins.) *Rutilus oregonensis* Snyder, Bulletin, Bureau Fisheries, vol. xxvii, 1907, p. 87, fig. 3. *Myloleucus formosus* Cope, (not of Girard), Proceedings, Academy Natural Sciences, Philadelphia, 1883, p. 143.

Siphateles columbianus (Snyder).—Columbia River, Malheur Lake Basin. (Not known from the Snake River or Bonneville Basins.) *Rutilus columbianus* Snyder, Bulletin, Bureau Fisheries, vol. xxvii, 1907, p. 92, fig. 4.

Siphateles obesus (Girard).—Lahontan system, including Eagle Lake. *Algansea obesa* Girard, Proceedings, Academy Natural Sciences, Philadelphia, 1856, p. 183. *Leucos obesus* Jordan, Report Chief, Engineers, 1878, pt. 3, Appropriation, N. N., p. 1614, and *L. formosus*, p. 1615. *Leucus olivaceus* Cope, Proceedings, Academy Natural Sciences, Philadelphia, 1883, p. 145, also *L. dimidiatus* Cope, p. 145, and *Siphateles vittatus* Cope, p. 146.

appear to possess some characters that are in a degree more or less distinctive.[a] The same is true of *S. obesus*, although apparently to a lesser extent. From *S. columbianus*, *S. bicolor*, and *S. formosus* the species in hand differs in having smaller scales, as illustrated by the following tables:

Scales lateral line	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Specimens of—																				
S. formosus	....	....	....	2	6	12	18	13	17	19	16	9	4	2	....	....	....	....	....	....
S. columbianus	1	8	11	10	22	15	10	9	5	4	1	....	....	....	....	....	....	....	....	....
S. bicolor	....	....	1	6	11	11	10	13	16	8	7	2	1	1	....	....	....	....	....	....
S. oregonensis	....	....	....	....	2	5	14	21	34	36	46	56	44	51	57	26	21	9	6	1
S. obesus	....	....	....	....	....	....	....	....	....	1	2	2	13	6	16	13	5	7	4	1

Scales before dorsal	22	23	24	25	26	27	28	29	30	31	32	33
Specimens of—												
S. formosus	1	8	10	16	13	9	2	....	....	....	....	....
S. columbianus	....	....	3	8	9	12	5	2	....	....	....	....
S. bicolor	1	2	2	11	2	1	....	....	....	....	....	....
S. oregonensis	....	....	3	8	9	27	23	34	36	20	10	4
S. obesus	....	....	....	....	....	4	9	17	16	18	3	2

The same genus is represented in Owens River and also in the Mohave River. Owens River specimens are very similar to those of *S. obesus* from the Lahontan system, while those from the Mohave seem to differ from all the others. Sufficient material for careful comparisons is not now available however.

S. obesus is both lacustrine and fluvial, reaching its maximum size and abundance in lakes and deep ponds, thriving in the lower courses of the rivers, but apparently not entering the swifter, clearer, and more shallow upper courses and tributaries. It is distributed almost universally throughout the Lahontan system, being like *S. oregonensis*, a species that maintains itself to the last in a dessicating basin.

S. obesus is a minnow with a large, robust body, large head, and relatively short fins. With advancing age and increasing size the head grows larger and the snout longer in relation to the body. Often a pronounced hump appears on the back behind the head. This hump is decidedly more prominent in alcoholic specimens than in life, however. Some individual difference appears in the depth of body, size of eye, height and length of fins, etc., but this is not found to be coordinate with locality, i. e., distinct basins, except that specimens from the Humboldt River and its tributaries seem to represent the extreme of large bodies and short, rounded fins.

There are from 50 to 60 scales in the lateral line, usually 53 to 56; 27 to 33 before the dorsal, usually 29 to 31; 12 to 16 before the lateral line. There are 8 rays in the dorsal fin and 7 or 8 in the anal. The number of scales and dorsal and anal rays aid in distinguishing between this and allied species:

Scales above lateral line	10	11	12	13	14	15	16
Specimens of—							
S. formosus	5	47	6	1	....	....	....
S. columbianus	....	17	21	1	....	....	....
S. bicolor	9	10	1	....	....	....	....
S. oregonensis	....	24	109	54	6	....	....
S. obesus	....	....	8	30	25	5	1

Number of gillrakers	8	9	10	11	12	13	14	15	16	17	18	19	20
Specimens from—													
Abert Lake	7	1	9	2	2	....	....	....	....	....	....	....	....
Silver Lake	....	....	3	12	3	8	2	....	....	....	....	....	....
Warner Lake	....	....	....	....	....	....	....	3	3	3	6	2	1
Alkali Lake	....	....	1	8	10	1	2	....	....	....	....	....	....
Summer Lake	....	....	....	....	....	3	11	5	2	1	....	....	....

An inspection of this table might lead to the supposition that well-defined local races, perhaps subspecies in the commonly accepted meaning of the term, might here be recognized. But investigation along that line shows that these races, if they may be so termed, are not of apparent geographical or distributional significance.

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[a] Bulletin, Bureau Fisheries, vol. XXVII, 1907, p. 87–92. The characters referred to are seen in body proportions, length of fins, etc. One illustration will suffice.

Dorsal rays	7	8	9	Anal rays	7	8	9	10	11
Specimens of—				Specimens of—					
S. formosus	....	....	59	*S. formosus*	1	46	12	....	....
S. columbianus	....	9	35	*S. columbianus*	....	43	1	....	....
S. bicolor	....	14	6	*S. bicolor*	5	15	....	....	....
S. oregonensis	1	130	61	*S. oregonensis*	54	135	3	1	1
S. obesus	....	86	3	*S. obesus*	21	62	....	....	....

There are 4 pharyngeal teeth on the right side; 5 on the left. Occasionally there are only 4 on the left, and sometimes there are 5 on both sides, in which case the supernumerary is slender and frail. The teeth are large, slightly hooked; a narrow grinding surface present. The posterior limb of the arch is equal to the anterior, or even larger, thus contrasting with that of *L. pectinifer*, which is much shorter than the anterior.

Number of teeth	4-4	4-5	5-5
Number specimens	2	33	12

The peritoneum is dusky in color, but not black. The alimentary canal is about equal in length to the entire length of the specimen. The air bladder extends the length of the abdominal cavity.

In life the color is deep olive above, lighter on the sides, white below; upper parts and sides with a very pronounced brassy reflection. Some of the scales are darker than the others; some are pinkish. Fins olive, with a little red. In some examples the belly is suffused with yellow and the fins are strongly tinged with red. Others are more green than olive, and some have the dark lateral color extending almost to the ventral surface. The pink and yellow tints are more prominent during the breeding season. The green is more pronounced in lake specimens. In an occasional individual a faint pinkish stripe may be detected along the side, its outline and extent being very indefinite. In the rivers the general color is sometimes lighter. Young specimens have a narrow dark stripe along the lateral line.

On May 24 this species had begun to spawn in Pyramid Lake, at least the eggs were then ripe, and the milt flowed from the males when they were touched. Small and medium sized examples caught in Lake Tahoe June 15 were not yet ready to spawn.

Large individuals (12 to 14 inches) do not appear to come near shore, at least during the daytime. During the summer they may be secured with a small spinner trolled at a depth of 20 feet or more. They bite readily when the hook is baited with angleworms. When still fishing, specimens were caught only at a long distance from the boat and at a depth of about 20 feet. A line so rigged that the bait would settle 20 feet below the surface, and cast out from shore where the bottom shelved off very rapidly, would generally secure specimens. Many smaller ones were taken in the seine and gill nets near shore along with *L. pectinifer*. Nets set at night were sure to be full of fishes in the morning.

Large schools of lake chubs gather about the wharves, fallen trees, and other sheltered places. At the mouth of Fallen Leaf Creek, Lake Tahoe, at times the rising water slowly spreads out over the meadows, and when covering the ground but a few inches is invaded by great schools of this species. After sundown they appear in countless numbers, thrashing about in the grass and rushes. When approached they either scurry off in great haste, sometimes diving into a bunch of grass, or settle down perfectly still. On the approach of daylight they return to deeper water. Dissection showed that they were probably feeding, certainly not spawning. Algæ, bits of plants, and fragments of insects were found in their stomachs.

Lake chubs when prepared for the table were found to be sweet and very palatable. They have at times been salted and sold in the markets as "whitefish." They contribute to the food of the larger trout and also to that of the water birds.

MEASUREMENTS OF SIPHATELES OBESUS.

	Pyramid Lake.					Walker Lake.									
Length of body....mm..	195	191	187	189	180	240	262	255	236	240	257	232	232	267	268
Length head	0.27	0.27	0.255	0.26	0.26	0.295	0.29	0.32	0.28	0.315	0.30	0.315	0.28	0.28	0.29
Depth body	.272	.27	.25	.28	.25	.295	.295	.31	.25	.315	.28	.28	.285	.28	.275
Depth caudal peduncle	.11	.11	.11	.11	.115	.115	.12	.13	.11	.115	.12	.12	.115	.115	.12
Length caudal peduncle	.22	.22	.22	.23	.22	.195	.20	.18	.20	.185	.19	.19	.21	.205	.20
Length snout	.075	.08	.07	.07	.076	.09	.085	.10	.095	.09	.085	.09	.08	.09	.08
Diameter eye	.05	.05	.05	.05	.05	.045	.045	.045	.045	.05	.043	.042	.045	.04	.045
Interorbital width	.08	.08	.08	.08	.08	.10	.10	.11	.095	.10	.095	.105	.09	.09	.09
Depth head	.175	.175	.17	.18	.17	.20	.21	.21	.195	.21	.20	.21	.20	.19	.20
Snout to occiput	.19	.195	.18	.18	.18	.21	.21	.225	.21	.22	.22	.22	.21	.205	.20
Snout to dorsal	.52	.53	.50	.525	.52	.545	.56	.58	.555	.595	.555	.58	.57	.57	.56
Snout to ventral	.54	.525	.52	.54	.51	.59	.57	.60	.58	.585	.60	.59	.56	.59	.57
Length base of dorsal	.115	.105	.115	.115	.115	.12	.125	.125	.11	.12	.12	.12	.11	.125	.12
Length base of anal	.10	.105	.095	.10	.105	.10	.10	.10	.09	.095	.105	.09	.09	.10	.09
Height dorsal	.17	.175	.17	.17	.17	.165	.17	.17	.165	.17	.17	.18	.17	.17	.165
Height anal	.14	.14	.135	.14	.14	.13	.125	.135	.14	.135	.14	.14	.135	.13	.13
Length pectoral	.18	.19	.185	.19	.19	.17	.165	.17	.17	.175	.17	.18	.175	.165	.17
Length ventral	.15	.16	.15	.15	.15	.15	.15	.155	.155	.15	.14	.15	.155	.145	.14
Length caudal	.25	.25	.24	.25	.25	.235	.25	.25	.25	.27	.245	.25	.25	.26	.235
Scales lateral line	55	57	58	58	58	59	55	53	57	53	58	56	54	56	53
Scales above lateral line	13	13	14	14	14	16	14	15	14	13	15	15	14	14	15
Scales below lateral line	7	7	7	8	7	7	8	8	8	7	8	8	7	7	7
Scales before dorsal	30	32	31	30	31	31	33	31	33	29	32	30	31	31	30

	Little Humboldt River.									
Length of body................mm..	116	121	121	106	142	89	95	92	90	89
Length head	0.265	0.27	0.27	0.275	0.275	0.27	0.28	0.27	0.28	0.26
Depth body	.275	.265	.26	.29	.27	.27	.27	.28	.28	.30
Depth caudal peduncle	.135	.122	.12	.125	.12	.11	.12	.12	.13	.12
Length caudal peduncle	.20	.21	.21	.22	.21	.22	.21	.21	.21	.22
Length snout	.075	.075	.08	.075	.08	.08	.08	.075	.07	.07
Diameter eye	.052	.05	.05	.06	.045	.06	.055	.06	.06	.055
Interorbital width	.095	.09	.09	.09	.09	.08	.09	.08	.095	.09
Depth head	.20	.195	.19	.21	.19	.19	.19	.195	.20	.19
Snout to occiput	.21	.20	.20	.21	.21	.20	.21	.21	.19	.19
Snout to dorsal	.55	.53	.54	.55	.55	.54	.53	.545	.54	.53
Snout to ventral	.555	.54	.54	.55	.56	.53	.54	.55	.55	.54
Length base of dorsal	.12	.12	.12	.12	.115	.12	.12	.13	.12	.12
Length base of anal	.10	.105	.10	.095	.09	.10	.095	.10	.09	.09
Height dorsal	.18	.175	.17	.18	.17	.20	.20	.18	.21	.19
Height anal	.14	.135	.14	.15	.14	.15	.16	.15	.17	.15
Length pectoral	.17	.16	.17	.17	.16	.20	.19	.20	.18	.17
Length ventral	.15	.14	.15	.15	.15	.17	.17	.16	.17	.16
Length caudal	.225	.22	.205	.225	.235	.24	.23	.24	.24	.24
Scales lateral line	58	59	56	56	57	57	59	56	55	58
Scales above lateral line	13	14	13	13	14	14	14	13	14	13
Scales below lateral line	8	8	7	8	8	8	8	8	8	8
Scales before dorsal	29	29	30	28	29	31	31	31	29	30

	Susan Creek.									
Length of body................mm..	100	89	85	82	75	81	81	79	76	70
Length head	0.29	0.265	0.27	0.27	0.26	0.27	0.28	0.29	0.29	0.28
Depth body	.26	.25	.26	.26	.28	.27	.26	.25	.28	.27
Depth caudal peduncle	.12	.125	.12	.12	.12	.12	.12	.12	.125	.12
Length caudal peduncle	.185	.20	.20	.22	.19	.21	.21	.21	.20	.20
Length snout	.09	.08	.075	.075	.075	.08	.08	.08	.08	.08
Diameter eye	.06	.06	.06	.06	.065	.07	.065	.06	.07	.065
Interorbital width	.09	.085	.09	.08	.085	.09	.09	.09	.085	.095
Depth head	.20	.19	.20	.20	.20	.20	.21	.19	.20	.20
Snout to occiput	.22	.21	.20	.23	.22	.21	.23	.21	.22	.21
Snout to dorsal	.56	.56	.55	.56	.54	.54	.54	.55	.57	.58
Snout to ventral	.56	.55	.54	.55	.55	.56	.55	.53	.56	.55
Length base of dorsal	.12	.12	.11	.11	.12	.11	.125	.125	.12	.12
Length base of anal	.09	.10	.10	.09	.10	.09	.10	.10	.085	.10
Height dorsal	.17	.185	.18	.19	.18	.19	.20	.21	.20	.20
Height anal	.13	.15	.15	.16	.16	.15	.16	.16	.155	.17
Length pectoral	.17	.165	.165	.17	.20	.19	.21	.18	.17	.18
Length ventral	.15	.15	.15	.16	.16	.16	.17	.16	.15	.15
Length caudal	.23	.24	.24	.26	.25	.25	.25	.27	.27	.26
Scales lateral line	54	56	58	55	55	54	55	55	56	54
Scales above lateral line	14	12	14	14	13	13	13	13	14	13
Scales below lateral line	8	7	8	8	7	8	7	8	8	7
Scales before dorsal	29	30	31	30	31	31	31	30	30	29

Leucidius, new genus of *Cyprinidæ*. Type *Leucidius pectinifer*, new species.

Teeth 5–5; slightly hooked, high and slender, the grinding surface rather narrow; base of arch long and slender, the limbs somewhat cylindrical. Gillrakers 29 to 36, the usual number being 31 to 34; closely apposed, long, slender, sharply pointed, almost straight; the inner edge with short, blunt papillæ; those at both ends of arch relatively long and well developed, the whole suggesting a fine-toothed comb. Pseudobranchiæ present; no barbels; premaxillary protractile; lateral line complete; peritoneum dusky; alimentary canal short; air bladder extending the entire length of the visceral cavity. Dorsals inserted almost directly above ventrals; dorsal and anal short. Scales large and regular; lateral line complete.

Leucidius is a lake minnow. It takes its place at once among an array of peculiar western genera, *Pogonichthys*, *Mylopharodon*, *Orthodon*, *Lavinia*, *Mylocheilus*, *Gila*, *Meda*, *Tiaroga*, and others.

Leucidius pectinifer, new species. Lake minnow.

This species has long escaped notice by reason of its close resemblance to *Siphateles obesus*. Preserved specimens of both species look remarkably alike until those of greater length than 8 or 10 inches are compared, when *S. obesus* begins to appear deeper and shows a more or less definite nuchal hump. In life *L. pectinifer* is lighter in color, whitish and silvery, while *S. obesus* is bronzy or brassy. Cope[a] apparently recognized both species in Pyramid Lake, for he says, when speaking of *S. obesus* (*L. olivaceus*), "This and the smaller *L. dimidiatus* swim in schools in the lake, as may be seen from the elevated road along the rocky shores, rippling the surface like a gust of wind." However, Cope's descriptions of both *L. dimidiatus* and *L. olivaceus* are based on specimens of *S. obesus*, as the types show.[c] Examples of *Leucidius pectinifer* were long ago collected with those of *S. obesus* in Washoe Lake and recorded as the latter species. The same oversight was later made in a collection from Eagle Lake. Cleaned pharyngeals of this species from the latter place, labeled *L. olivaceus*, led to the erroneous statement that the teeth of *L. olivaceus* numbered 5–5.[d] *Leucidius pectinifer* might on superficial examination be confused with *Richardsonius microdon*, but a glance at the gillrakers will serve to identify it among other western minnows. (See fig. 5.)

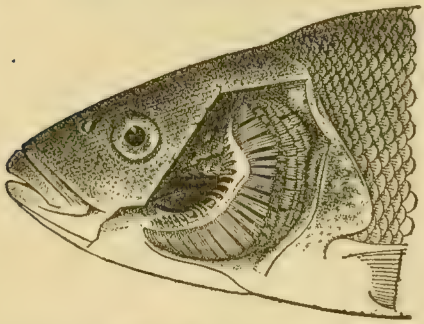

FIG. 4.—*Siphateles obesus*. Winnemucca Lake, Nev.[b]

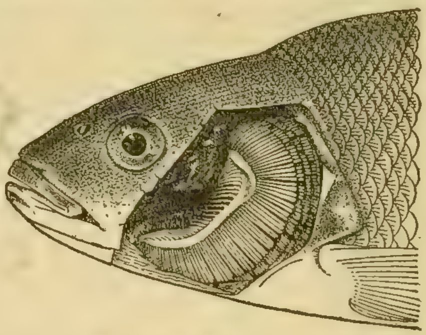

FIG. 5.—*Leucidius pectinifer*. Pyramid Lake, Nev.

Description of type no. 76304, United States National Museum, a female specimen measuring 237 millimeters, from The Willows, Pyramid Lake, Nev., June 2, 1913. (See fig. 6.)

Head 3.7 in length to base of caudal; depth 3.6; depth caudal peduncle 9.3; eye 5.3 in head; snout 3.5; maxillary 3.7; height dorsal 6 in length; anal 7.3; length pectoral 6.7; ventral 6.7; caudal 4; dorsal rays 8; anal 8; scales lateral series 57; between lateral line and back 13; between lateral line and ventral fin 8; between occiput and dorsal 30.

Depth of body somewhat less than twice its width, the deepest part being below origin of dorsal fin. Dorsal contour rather angular, sloping forward from origin of dorsal to tip of snout, this part of the outline somewhat convex, and backward to caudal peduncle, the outline slightly concave. Ventral contour rather evenly convex. Head pointed; mouth oblique, but not enough so to interfere with the curved ventral contour of head; lower jaw slightly projecting; premaxillary protractile. Eye large, its diameter less than length of snout and greater than half the width of interorbital space. Posterior nostril elongate, the anterior semicircular. Teeth (paratype) in a single row, 5 on each side, slightly hooked at tip; a narrow grinding surface present. They are higher, lighter, and the arch is more slender than in *S. obesus*. Gillrakers long and slender, so closely apposed that the space between two of them is narrower than the base of either. Pseudobranchiæ restricted to a small area. Scales large, very regular, somewhat crowded on the throat. Lateral line decurved anteriorly and then extending straight along side of body and middle of tail. Origin of dorsal midway between tip of snout and last scale on base of caudal. Edge of anal straight. Ventrals inserted directly beneath origin of dorsal; their edges rounded. Upper edges of pectoral longest. Caudal deeply forked.

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[a] Proceedings, Academy Natural Sciences, Philadelphia, 1883, p. 145.

[b] See p. 60 for description of species.

[c] When at the Academy of Natural Sciences in Philadelphia, Mr. Henry W. Fowler kindly allowed the writer to examine the types of both species.

[d] Bulletin, Bureau Fisheries, vol. XXVII, 1907, p. 87.

The preserved specimen is dusky above, light yellowish beneath; the scales on sides broadly edged with dusky color; caudal with a distinct dusky edge. In life, olive above, lighter on the sides, white below; scales with a bright silvery sheen. Dorsal olive; caudal olive, but lighter than the dorsal; other fins strongly tinted with red.

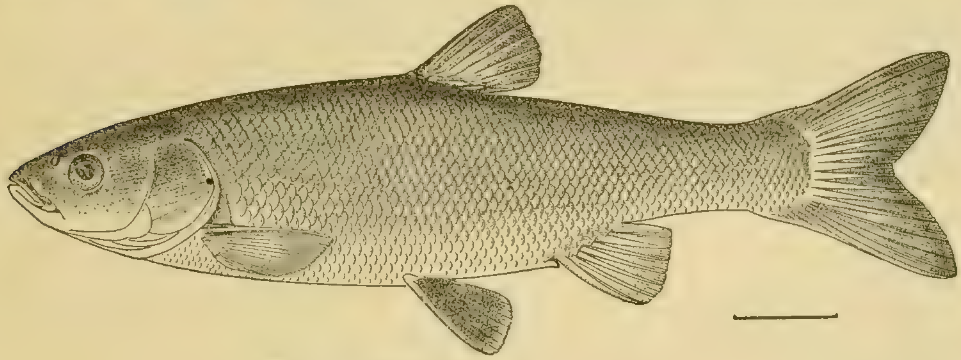

Fig. 6.—*Leucidius pectinifer*. Type. Lake minnow.

There are from 29 to 36 gillrakers in this species; usually 31 to 33:

Number of gillrakers	29	30	31	32	33	34	35	36
Number of specimens	1	4	7	5	9	4	1	2

The teeth are invariably 5-5. The scales in the lateral series number from 53 to 63; between lateral line and back 13 to 15; between occiput and dorsal fin 29 to 35; between ventrals and lateral line 7 or 8.

Scales in lateral series	53	54	55	56	57	58	59	60	61	62	63
Specimens	2	1	8	2	18	22	4	3	9	7	5

Scales before dorsal	29	30	31	32	33	34	35
Specimens	2	18	17	20	19	2	3

Scales above lateral line	13	14	15
Specimens	19	51	11

Other measurements follow:

MEASUREMENTS OF LEUCIDIUS PECTINIFER.

PYRAMID LAKE, THE WILLOWS.

Length of body....mm..	196	201	186	177	172	182	184	187	184	166
Length head	0.27	0.27	0.27	0.265	0.265	0.26	0.27	0.265	0.26	0.26
Depth body	.255	.26	.26	.27	.25	.265	.27	.26	.25	.265
Depth caudal peduncle	.105	.115	.115	.125	.11	.12	.115	.112	.113	.115
Length caudal peduncle	.225	.195	.22	.21	.225	.215	.22	.23	.225	.21
Length snout	.08	.08	.075	.07	.07	.075	.07	.07	.075	.07
Diameter eye	.05	.048	.05	.05	.05	.05	.05	.05	.05	.05
Interorbital width	.08	.08	.078	.08	.085	.08	.085	.08	.08	.08
Depth head	.17	.175	.172	.175	.18	.18	.18	.175	.17	.18
Snout to occiput	.19	.20	.195	.19	.19	.19	.20	.185	.195	.19
Snout to dorsal	.52	.525	.52	.53	.52	.52	.52	.515	.525	.52
Snout to ventral	.525	.53	.545	.54	.53	.53	.54	.53	.53	.525
Length base of dorsal	.11	.11	.115	.11	.11	.12	.11	.105	.10	.115
Length base of anal	.095	.095	.10	.09	.095	.10	.095	.09	.09	.10
Height dorsal	.165	.16	.17	.165	.175	.175	.165	.15	.16	.175
Height anal	.135	.13	.13	.13	.15	.14	.135	.12	.13	.13
Length pectoral	.17	.165	.17	.185	.195	.19	.19	.15	.18	.17
Length ventral	.145	.14	.14	.145	.16	.155	.155	.13	.15	.15
Length caudal	.265	.26	.27	.25	.265	.26	.24	.23	.255	.255
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	8	8	8	8	8	8	8	8	8	8
Scales lateral line	58	63	62	57	57	62	61	59	58	57
Scales above lateral line	14	15	15	14	15	13	14	14	14	14
Scales below lateral line	7	8	7	8	7	7	8	8	8	8
Scales before dorsal	29	32	31	33	35	31	33	33	31	29

LAKE TAHOE, TAHOE CITY.

Length of body....mm..	141	124	103	119	121	123	148	140
Length head	0.24	0.25	0.26	0.25	0.255	0.255	0.25	0.245
Depth body	.29	.27	.29	.26	.26	.26	.25	.24
Depth caudal peduncle	.113	.12	.13	.12	.115	.11	.12	.11
Length caudal peduncle	.22	.22	.23	.22	.22	.22	.215	.22
Length snout	.072	.068	.07	.07	.07	.07	.07	.065
Diameter eye	.052	.052	.06	.055	.055	.05	.05	.05
Interorbital width	.08	.085	.09	.08	.08	.08	.08	.08
Depth head	.18	.182	.18	.17	.18	.175	.18	.17
Snout to occiput	.19	.185	.18	.18	.19	.18	.19	.18
Snout to dorsal	.525	.52	.53	.52	.53	.54	.53	.52
Snout to ventral	.525	.52	.53	.52	.51	.53	.53	.53
Length base of dorsal	.11	.115	.11	.115	.11	.12	.11	.11
Length base of anal	.09	.10	.10	.09	.09	.10	.10	.10
Height dorsal	.19	.19	.20	.195	.19	.18	.18	.17
Height anal	.13	.145	.14	.15	.14	.14	.15	.15
Length pectoral	.17	.19	.18	.185	.18	.18	.19	.17
Length ventral	.142	.155	.17	.155	.16	.16	.165	.155
Length caudal	.25	.265	.26	.265	.26	.255	.265	.25
Dorsal rays	8	8	8	8	8	8	8	9
Anal rays	8	8	8	8	7	8	8	8
Scales lateral line	56	58	60	59	55	55	56	55
Scales above lateral line	13	13	14	13	13	13	13	14
Scales below lateral line	8	7	8	8	7	7	8	7
Scales before dorsal	29	30	32	32	33	30	28	30

This seems to be the most abundantly represented species in Pyramid Lake, approaching the shore at times in enormous schools. Perched on a high tufa crag near the shore one may observe countless numbers of these fish slowly passing through the clear water. From the cliffs above they resemble large purple clouds reflected from the green surface of the lake. They bite eagerly at a baited hook, a small spoon, or an artificial fly. It is said that during the winter very few are seen.

On May 16 the writer began observations on the western side of Pyramid Lake at The Willows. The weather was then cold and squally, the lake rough and forbidding. Relatively few fishes were seen, although large schools of suckers were spawning and a few minnows might be observed here and there among the suckers and in the algæ, while an occasional trout was caught by the Indians. On May 20 the weather suddenly settled and became warm. As the sun went down, its last rays from over the mountains fell on the surface of the lake, which was as calm and placid as a great mirror. About 2 o'clock on the following morning there was heard a vigorous lapping of the water, which in the quiet air appeared entirely without cause until it was found to accompany the leaping of vast numbers of fishes. Far out and up and down the shores the surface of the water fairly boiled. Spring had come, and with it, in the dim light of the early morning, myriads of fishes from the depths of the lake. Daylight revealed them everywhere, along the shore, among the bowlders, and in the algæ, hovering in enormous schools over the bars and moving about in the clear water of the sheltered bays. From this time the suckers rapidly disappeared, while the large trout approached the shore in their eagerness to feed on the luckless minnows.

Most of the fishes engaged in this particular migration were *L. pectinifer*, although many examples of *S. obesus* were seen among them. At this time the latter were often taken in deep water with a troll at some distance from shore. Most of these fish (*L. pectinifer*) were not ready to spawn, and no ripe individuals were seen until May 24, after which date spawning soon began.

Residents report that during the summer large numbers of minnows frequent the inshore waters, but that in September they disappear and are seen no more until the following spring. Late in the summer great numbers of small minnows swarm in the shallows near shore. Young specimens of this species were taken from several schools in protected, shallow bays in Winnemucca Lake, June 17, 1913. They were of two distinct sizes, measuring, respectively, 42 to 58 and 65 to 80 millimeters. There was a black lateral stripe extending along the side, broader, darker, and more definite in outline posteriorly and enlarging greatly near base of caudal fin, where there is a more or less distinct dark spot. The scales of the lateral line are very thin, the tube is large, and when the scales are rubbed off the line appears broken or incomplete.

Large numbers of the species fall a prey to gulls, cormorants, and pelicans, the latter scooping them up in great numbers to feed their young. They contribute largely to the food of the trout. They make excellent pan fishes, although very bony.

The species appears to be entirely lacustrine.

Agosia robusta Rutter. Black minnow.

The name *robusta* was first applied by the describer of this species[a] to examples of *Agosia* found in tributaries of the Truckee and Susan Rivers. It was later[b] used to include fishes of the genus found in streams of the western slopes of the Sierras which flow into the Sacramento and San Joaquin Rivers. It was at first thought to be characterized by the blunt, rounded snout, the heavy body, incomplete lateral line, absence of scattered brown scales, shorter pectorals, greater development of rudimentary caudal rays, scales in lateral series 56 to 57, and in the presence of a silvery stripe across the cheek. Later it was seen to be "quite variable," and, in the hands of its describer, it was assuming the same complex medley of variations which are found in *A. carringtoni* or *A. nubila carringtoni* of later writers. It now appears that the name must be restricted to the *Agosia* of the Lahontan system or else abandoned entirely, for if its range is extended to include even a part of the Sacramento system its variation becomes so great that it can not now be differentiated from the form or forms occupying the Oregon Lake region or the upper Columbia. As yet the present writer is unable to find any character or set of characters which will distinguish *Agosia robusta*, and the name is therefore only provisionally retained.

A large series of specimens from the Lahontan system are at hand, and from these the following observations are made:

The snout is short and evenly rounded from its tip to the interorbital space. It is not blunt, nor does it project much beyond the mouth in any case. The under jaw is included. The maxillary is protractile, no frenum appearing. Barbels are present on both sides, on one side only, or absent altogether. When present, they are occasionally long and prominent, but at times they are so short as to almost escape notice. When one only is present, it is indifferently on the right or left side.

Barbels	Present.	On one side.	Absent.
Specimens from—			
Susan Creek	13	4	10
Carson River	10		
Fallen Leaf Creek		8	11
Humboldt River Palisade	8	2	10
Star Creek	14	5	1
Marys Creek	9	5	4
Quinn River	5		15

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[a] Bulletin, United States Fish Commission, vol. XXII, 1902, p. 148.

[b] Bulletin, United States Bureau Fisheries, vol. XXVIII, 1907, p. 139.

The gillrakers are short and stubby; 6 or 7 small protuberances. The body is deep and robust; no more so, however, than many examples from the Columbia or Bonneville systems. The lateral line sometimes extends to the last scale, although in most cases it is less complete. It often differs on opposite sides of the body, and sometimes it extends the entire length, but interrupted at irregular intervals. It is found to end anterior to the dorsal or at any point between the dorsal and caudal fins.

Lateral line	Almost complete.	Ends before anal fin.	Ends near middle of anal.	Ends anterior to dorsal.
Specimens from—				
Susan Creek	13	5	1	8
Carson River	1	....	7	2
Fallen Leaf Creek	1	....	18	....
Humboldt River Palisade	5	....	12	3
Star Creek	7	....	9	14
Marys Creek	12	5	1	....
Quinn River	6	3	3	8

No scattered brown scales occur, their absence, however, not being characteristic of Lahontan specimens alone. The dorsal is almost always inserted well behind the ventrals, nevertheless the distance is found to vary from a point near a vertical through the insertion of ventrals to almost halfway between their bases and the anal opening. The pectorals are usually short, not reaching the ventrals. Specimens with longer fins are easily found, the pectorals at times extending well beyond the bases of ventrals. Usually there are not less than eight fully developed rays in the ventral fin. When depressed their tips fall short of the anal opening or extend even to the origin of the anal fin. The edges of the fins are truncate or rounded, never falcate. Membranous stays do not appear behind the bases of the ventrals. Rudimentary caudal rays number from three to six. A more or less definite, broad, dark, lateral stripe is present, although in some cases it is poorly defined and seen only on the caudal peduncle. Usually a distinct narrow stripe appears along the side of the abdomen. Dark blotches of variable size are often present, but the dark pigment is not confined to particular scales. Examples from the desert are lighter than those from wooded areas, the stripe being present on individuals from both regions. This stripe is not black and sharply defined as in specimens of *A. nubila* from the coast region of Oregon and Washington. The bright silvery area observed by Rutter soon disappears under the action of preservatives.

In life the color is yellowish olive above, growing brassy on the sides and yellowish beneath. The spots and stripe are olive black. End of maxillary and small space behind it, a spot posterior to edge of opercle, median area of throat and breast, a broad axillary area of both pectorals and ventrals, and a narrow space along base of anal, bright crimson with a slight brassy reflection. Fins tipped with yellowish red.

The teeth in 10 examples were 4, 1–1, 4, strongly hooked, and without grinding surface.

The alimentary canal is not longer than the entire length of the individual. The peritoneum is jet black, occasionally lighter. The bladder extends over about four-fifths of the visceral cavity. A female caught at Tahoe City June 27 was full of nearly ripe eggs.

The scales are very small, convex, rounded in outline, and possess both basal and apical radii. They are almost if not altogether indistinguishable from those of *Hesperoleucus mitrulus*, thus rendering their minute structure useless as a generic character.

This species inhabits both streams and lakes. In the rivers it is most often taken on the ripples. In lakes it frequents the shallow water, swimming near the bottom, or in crevices between rocks. From above, when seen in the water, the color is decidedly black. In the lakes it was taken with hook and line, a method which will often secure very small fishes where the net fails on account of deep, clear water or rough bottom.

Agosia nevadensis and *A. velifer* are very distinct from this form and are easily recognized.

MEASUREMENTS OF AGOSIA ROBUSTA.

	Fallen Leaf Creek, near Tallac, Lake Tahoe.					Susan Creek, 10 miles below Susanville.				
Length of body.................mm..	60	58	58	56	79	52	60	55	58	60
Length head	0.24	0.26	0.24	0.23	0.26	0.26	0.26	0.25	0.25	0.25
Depth body	.25	.20	.25	.22	.26	.25	.22	.21	.24	.225
Depth caudal peduncle	.115	.115	.105	.12	.10	.12	.11	.11	.12	.12
Length caudal peduncle	.26	.26	.24	.25	.26	.21	.23	.23	.25	.24
Length snout	.08	.10	.08	.08	.08	.085	.10	.07	.08	.08
Diameter eye	.06	.055	.06	.06	.045	.06	.05	.05	.05	.055
Interorbital width	.07	.07	.075	.065	.06	.07	.08	.08	.08	.07
Depth head	.17	.17	.17	.16	.16	.18	.16	.16	.18	.17
Snout to occiput	.21	.21	.21	.20	.20	.22	.20	.20	.20	.20
Snout to dorsal	.56	.53	.55	.54	.54	.58	.55	.55	.55	.56
Snout to ventral	.50	.47	.50	.48	.51	.52	.54	.51	.48	.51
Length base of dorsal	.11	.115	.12	.12	.11	.11	.10	.10	.10	.12
Length base of anal	.10	.10	.095	.11	.10	.09	.10	.085	.09	.08
Height dorsal	.19	.20	.19	.19	.16	.17	.165	.18	.16	.16
Height anal	.16	.18	.16	.18	.16	.17	.16	.16	.16	.16
Length pectoral	.20	.23	.19	.22	.17	.18	.17	.17	.17	.17
Length ventral	.15	.17	.15	.16	.13	.15	.14	.15	.13	.14
Length caudal	.26	.25	.24	.25	.235	.24	.23	.22	.23	.23
Dorsal rays	8	8	9	8	7	8	8	7	7	8
Anal rays	7	7	7	7	8	7	7	7	7	7
Scales lateral line	75	76	73	68	70	67	67	73	68	65
Scales above lateral line	13	13	13	13	13	12	14	13	12	14
Scales below lateral line	9	9	9	10	10	9	9	10	9	11
Barbels	1	0	0	0	0	2	2	2	0	0

Coregonus williamsoni Girard. Mountain whitefish.

Sufficient material for a careful comparison of whitefish from the Lahontan and Columbia systems is not at hand. They seem to be alike, but the appearance of differences when series of each are compared would not be regarded with surprise.

The species is found in the Truckee, Walker, and Carson Basins, it was reported from the Humboldt, but no evidence of its occurrence elsewhere in the system was found. It spawns in October, large numbers then moving up the tributaries of Lake Tahoe. The migration is said to last about two weeks, being at its height near the middle of the month. Males collected at that time had tubercles on the posterior part of the body and tail, both above and below the lateral line.

An example from Carson River, near Genoa, was silvery in life, tinted with pale olive above, white beneath. This specimen measured 395 millimeters. A smaller one, 185 millimeters long, was silvery, somewhat darker above than below. When the body was turned, indistinct parr marks appeared in some lights on the sides, which became more evident after preservation. Examples from 150 to 230 millimeters long, taken at Lake Tahoe, show no parr marks, while others measuring 95 to 145 millimeters, collected in Fallen Leaf Creek, are broadly marked along the sides. These usually have nine almost square, round, or somewhat oval dark spots on the sides, each of which is about four scales wide, their edges extending just below the lateral line. The first is immediately behind the gill opening; the last at the base of the caudal fin. Those near the middle of the body are largest. Occasionally a spot is very small or absent, or a supernumerary may appear anywhere along the median line. Above this row are many smaller spots, close together and without any definite arrangement. With growth the smaller spots are first to disappear.

The mountain whitefish seems to be particularly fond of the eggs of spawning fishes, and sometimes their stomachs will be found filled with the eggs of their own species. It rises to the fly at times, is as game as a trout, and by some is preferred as a food fish.

A further comparison of specimens of this species with those of *C. oregonus* Jordan and Snyder, from the Willamette River, fully warrants the recognition of the latter.

MEASUREMENTS OF COREGONUS WILLIAMSONI.

	Lake Tahoe.						Fallen Leaf Creek.					
Length of body..........mm..	238	228	207	200	187	185	114	121	115	103	102	101
	♀	♀	♀	♀	♀	♂						
Length head	0.195	0.205	0.215	0.22	0.22	0.215	0.23	0.21	0.22	0.23	0.23	0.24
Depth body	.18	.20	.21	.195	.20	.195	.20	.18	.19	.17	.19	.17
Depth caudal peduncle	.06	.065	.06	.06	.06	.065	.065	.06	.065	.06	.06	.06
Length caudal peduncle	.14	.135	.135	.14	.145	.14	.14	.15	.16	.15	.15	.14
Length snout	.06	.065	.065	.065	.065	.06	.065	.07	.07	.065	.06	.07
Length maxillary	.055	.055	.06	.06	.06	.055	.065	.065	.065	.065	.065	.07
Diameter eye	.05	.05	.05	.05	.05	.055	.06	.06	.065	.06	.065	.07
Interorbital width	.065	.065	.06	.06	.06	.06	.065	.06	.06	.07	.065	.065
Depth head	.135	.15	.145	.14	.15	.145	.15	.14	.14	.145	.15	.145
Snout to occiput	.16	.17	.17	.17	.18	.18	.18	.17	.17	.18	.185	.19
Snout to dorsal	.335	.455	.45	.46	.46	.46	.45	.445	.43	.44	.445	.445
Snout to ventral	.53	.535	.535	.55	.55	.555	.51	.51	.50	.51	.51	.53
Length base of dorsal	.125	.12	.115	.11	.105	.11	.12	.12	.12	.12	.13	.125
Length base of anal	.105	.10	.095	.095	.10	.10	.10	.105	.11	.115	.11	.11
Height dorsal	.135	.125	.13	.12	.14	.13	.14	.13	.135	.15	.13	.125
Height anal	.11	.11	.11	.10	.105	.11	.12	.11	.105	.12	.11	.12
Length pectoral	.15	.155	.165	.165	.175	.16	.17	.16	.15	.17	.175	.17
Length ventral	.125	.13	.12	.13	.13	.135	.13	.13	.11	.14	.12	.12
Length caudal	.165	.17	.17	.17	.18	.18	.22	.205	.20	.215	.20	.20
Dorsal rays	12	12	11	11	12	12	11	11	11	11	12	12
Anal rays	12	11	12	....	11	11	12	11	12	....	11	11
Scales lateral series	82	89	85	85	87	85	82	89	86	86	80	85
Scales above lateral line	8	9	9	9	9	9	10	10	10	10	9	10
Scales below lateral line	7	8	8	8	8	7	7	8	8	8	8	8
Scales before dorsal	30	32	30	31	33	32	33	34	34	32	31	31

Salmo henshawi Gill and Jordan. Tahoe trout.

This trout is best known to ichthyologists and anglers from fish caught in Lake Tahoe, in its numerous tributary streams and small lakes, and in the upper portions of the Truckee River. Here its most striking characteristic is the dark-olive body with an array of large black spots scattered almost uniformly over the entire surface. The species is distributed throughout the entire Lahontan system, however, and living under greatly diversified conditions it seemingly reacts to its surroundings, appearing in a medley of variations of color, such as are not often observed among individuals of a single species.

Examples in bright nuptial dress may be seen in Lake Tahoe in May and early June. The males are then of a dark yellowish-olive color, with faint metallic reflections, the dark color being uniform from the back to the ventral surface. On the side is a broad, pinkish stripe, indefinite in outline, but about 10 scales wide and located mostly below the lateral line, originating at the opercle and extending to below the adipose fin, beyond which it gradually fades out and disappears. Each scale included in this stripe and also in a broad area above and below is narrowly edged with pale yellow. The opercle, preopercle, subopercle, and a triangular spot above the axil of pectoral are scarlet or yellowish scarlet. The under surface of the lower jaw has two parallel stripes of bright red, the color not extending on the mandibular side of the membranes. There is a patch of bright red on the tongue beneath the tip. The inner edge of the shoulder girdle is bright red. One or more small orange spots may often be found on the head, especially on the cheeks and jaws. The entire head and body, together with the unpaired fins, are marked with dense, brownish-black spots, usually larger than the pupil, and rounded oval in outline, widely spaced and fairly regular in distribution. On the dorsal fin the spots are arranged in five pretty well defined rows, parallel with the outline of the back. The adipose fin bears two or three spots; they are numerous on the caudal, but not more than six or seven occur on the anal, usually at the base. Females are similarly colored, though much lighter and with more metallic luster.

Males often vary toward lighter tints, while some females are occasionally darker than the others, sometimes rendering the determination of sex on color alone very difficult. Frequently a very light-colored, silvery specimen of either sex appears. Such fishes are distinguished by the bright metallic luster of the sides and also by having smaller and more elongate spots. These are known as silver trout, and are said to frequent the greater depths. They represent *Salmo clarkii tahoensis* Jordan and Evermann.[a] A specimen of this sort measuring about 14 inches was caught near the mouth of Cascade Creek. It was very silvery in color, lacking the red and rich olive shades of the more usual type. The spots were small and elongate, contracted laterally instead of from all sides. A silver trout, caught by Mr. Ralph Lowe, near Brockway, measuring 23 inches and weighing 5 pounds, was dull silvery over nearly the entire surface, the upper parts tinted with brownish and having purplish reflections. A broad, indistinct lateral stripe of light pink extended posteriorly to near the anal fin. The head was dusky above, the cheeks silvery, with a pinkish tint, the skin beneath the maxillaries bright red. This specimen was apparently 6 years old, as indicated by an examination of the scales. These so-called silver trout sometimes attain a great size, one having been caught which weighed 29 pounds.[b]

The trout seen in the smaller lakes and streams of the Tahoe Basin were like those of the lake itself. Those seen in the Truckee River near Lake Tahoe, at Truckee, and farther down the river were much like those of the lake, the spots being usually smaller and possibly more numerous.

Trout are at times rather common throughout the entire course of the Truckee River. Before the introduction of irrigation dams, power plants, factories, and sewers they were abundant, but now the partly diverted, interrupted, and contaminated river is a very precarious summer home for the larger fishes at least.

On the appearance of rain in the mountains, and the following rise of the river, trout begin to migrate from Pyramid and Winnemucca Lakes, passing up the stream in a leisurely way, briskly running the rapids, or loitering about in the deep pools. They often pass the great bend in December or even as early as October and continue upstream, migrating in waves or schools and series of schools. With the advancing season the fish grow more numerous, appearing in incredible numbers as the run reaches its maximum. The trout of this migration are locally known as redfish.

After becoming acquainted with the dark and comparatively small Tahoe trout, one regards the huge redfish with amazement, its long and powerful body gleaming with flashes of gold and silver, and the great red cheek spot glowing like a coal of fire. By some observers it is regarded as entirely distinct from the Tahoe trout and also from the smaller fishes of a later run. The Piutes call it "Tomoo-agaih," or winter trout.

A large male redfish dipped from the pool below the dam at Thisbe (March 26) was colored as follows: Whole body suffused with pink and yellow, the color approaching vermilion in some lights or darker red in others, the yellow with metallic reflections. The yellow color is more intense above and below, the pink brightest in the region of the lateral line, but not distinctly outlined as a stripe. Opercle bright, livid red; subopercle like body; preopercle reddish yellow, much brighter than body, but duller than opercle. An indefinite, small pinkish spot midway between eye and opercle. A few deep-orange, coin-shaped spots somewhat smaller than eye, scattered here and there on the body near bases of pectorals and on the breast. The caudal fin is yellow, the dorsal suffused with yellow, the paired fins with purplish red. The area beneath the mandible is strongly marked with bright red, the color confined to the side next to the branchiostegals. More brilliantly colored examples are often seen where the red of the opercle is more livid and spreads to the shoulder girdle, the lateral stripe better defined and more intense in color, and the entire head and body of a brighter hue. The females are similar though paler in color. The small orange spots referred to are remarkable in that they appear, without regularity, on any part of the body except in the region of the lateral line. One was seen on the lower jaw, another on the base of the caudal, and one on the adipose fin. In addition to the bright colors noted above, the head and body are sprinkled with black spots which are smaller than in the Tahoe trout. The red color beneath the jaw is apparently always present in the redfish.

The migration of the redfish ceases in March. The running fishes do not appear to go upstream farther than the approach of the swift water of the canyon above Verdi.

As the redfish migration slowly wanes, large numbers of smaller trout enter the Truckee River and pass up with considerable rapidity. Smaller, generally darker in color, and more heavily spotted than those of the preceding run, and arriving with the spring, they are called by the Piutes "Tama-agaih," meaning spring trout. The native name is passed on by the anglers as plain tommy. Like the redfish, the movements of the tommies are apt to be somewhat irregular, depending on the state of the river, appearing and passing in large numbers while the water is rising and being less numerous when it is low. Advance scouts of the tommies come in with the last of the redfish, while an occasional lingering individual of the latter is overtaken by the advancing hordes of tommies. But on the whole the two migrations are distinct, and fishes belonging to each may be distinguished with some degree of certainty. The second migration usually occurs in April, being well over by May 1. Individuals which have not yet spawned may be found in the river during May and even later. By the latter part of June, certainly by the middle of July, the lower part of the river is practically clear of large trout.

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[a] Bulletin 47, United States National Museum, p. 2870.

[b] Jordan and Evermann, Bulletin 47, United States National Museum, p. 493 (*Salmo mykiss henshawi*) and p. 2870 (*Salmo clarkii tahoensis*).

At times many very silvery tommies appear in the lower Truckee, and again only an occasional one will be seen. Silvery redfish also occur. These are not to be confused with the emerald trout, which have not been reported from the river.

In Pyramid and Winnemucca Lakes trout abound, and they grow to a large size. Specimens of 9 or 10 pounds are common, while sometimes examples weighing over 20 pounds are caught. Considerable variation in color is found here, especially early in the season, when breeding fishes are returning from the river. An example 2 feet long, taken in Pyramid Lake May 29, in life was clear greenish olive on the upper surface, this color becoming diffuse on the sides, where it gave place to silvery, strongly tinged with pink, the ventral surface of the body, throat, and chin being white. The whole dorsal surface when seen from the side appeared silvery with a suffusion of pink, instead of greenish olive, as when viewed from above. Cheeks pinkish, the upper edge of opercle brassy. Paired fins and anal tinted with orange red. Dorsal and adipose fins like the back. A red gash present on the under mandible. Small black spots scattered rather evenly over head and body, varying in size from about a third the diameter of pupil to mere specks. They were largest on the upper surface and on the caudal fin. Many examples similar in color were seen. The red was never entirely absent from the throat, and small, round, brassy spots were frequently found on the head and body. Large, fat examples are sometimes taken, the general color of which is very pale and silvery, the spots being few and small, exact counterparts of the silver trout of Lake Tahoe. Several specimens taken on the western side of Pyramid Lake late in May were brilliantly colored and dark like the migrating trout. Their fins were frayed, they had spawned, and it was quite apparent that they had but recently returned from the river. Rarely an individual is caught which has no spots below the lateral line except on the caudal fin and only a few above. Trout from Winnemucca Lake are like those from Pyramid Lake. An examination of many from both localities gave the impression that those from the former were somewhat lighter in color.

Anglers usually distinguish trouts by color and form, and in the Truckee Basin they generally recognize 6 varieties: In Lake Tahoe, the Tahoe trout, dark in color, with large spots; the silver trout, silvery in color, with small, elongate spots, body deep and heavy; the royal silver trout, deep blue above and silvery on the sides, with few or no spots. In the lower Truckee River and the lakes, the redfish, migrating from Pyramid and Winnemucca Lakes, brilliant in color, the red cheek especially prominent; the tommy, a smaller and relatively large spotted fish, which appears in a separate run following that of the redfish; and, finally, the greenback (emerald trout) of the lakes, green above, silvery on the sides, and with very few spots. Except the royal silver and the emerald trouts, these appear to be representatives of the same species, no character or set of characters having been found which will serve to distinguish between any of them. The introduction of marked fingerlings of the redfish into Lake Tahoe and of small Tahoe trout into Pyramid Lake might lead to interesting results.

Questions at once arise regarding the two migrations of trout in the lower Truckee River, and it may be briefly stated that nothing has been accomplished by way of explanation except negatively. The redfish and tommies are found in both lakes, and the migrations appear to proceed from both at about the same time.

The following table is presented to aid in expressing the numerical variation seen in the spotting of trout from different localities. Typical specimens were selected, and a line drawn along the side of the body from the gill opening to the middle of the base of the caudal. This was crossed by another passing vertically through the anal opening, thus separating body and tail and dividing each into an upper and lower half.

NUMBER OF SPOTS ON TROUTS FROM DIFFERENT LOCALITIES.

Locality	Lake Tahoe.		Truckee River.				Pyramid Lake.		
			Redfish.		Tommy.				
Length of specimen . . . mm.	370	390	675	720	500	555	529	584	400
Spots on head	55	60	16	12	44	68	65	20	13
Body above line	95	103	100	44	115	92	102	51	43
Body below line	113	53	45	49	175	159	121	16	0
Tail above line	43	45	48	39	63	59	52	42	40
Tail below line	59	44	25	31	57	82	56	28	7
Dorsal fin	36	42	86	103	55	45	66	52	41
Adipose fin	3	5	4	5	2	4	8	6	4
Caudal	66	93	234	284	145	162	184	65	95
Anal	28	20	27	26	23	16	12	6	17

The native trout seen elsewhere in the Lahontan system belong to this species. Those of the Humboldt, Carson, and Walker Rivers are lighter in color than fishes from Lake Tahoe. Like other trout they are darker in deep, shaded water and lighter and more silvery in the open rivers. Large trout of this species are found in the upper part of Walker Lake, where the water is comparatively fresh.

S. henshawi is a more slender trout than the rainbow. The head is longer and more pointed, and in some cases the body is very elongate.

MEASUREMENTS OF FRESHLY KILLED SPECIMEN.

Total length . . . inches. .	22¼	23¼	29½	25½	21¾	25½	24	27½	26¾	24	23	26⅜	21¾	20¼
Depth . . . do. . . .	4¼	3⅞	6¼	4½	3¾	5⅜	4	5¼	5½	4⅜	4¼	4⅛	3⅝	3⅝
Depth caudal peduncle . . . do. . . .	1⅝	1⅝	2 3/16	1⅞	1¾	2	1⅝	2	1⅞	1¾	1¾	1⅞	1½	1½
Length head . . . do. . . .	5¼	. . . . . .	6⅜	5⅞	4⅝	5¾	5½	5¾	5¾	5½	4⅞	5¾	4 7/16	4
Weight . . . pounds. .	3¼	3	8¾	4½	2¾	5¾	3⅛	7	5¾	3¾	3¼	3¾	2⅜	2⅝

In addition to the above, the following measurements and weights may be of interest. The fishes were taken in Pyramid and Winnemucca Lakes.

Length.	Weight.	Length.	Weight.	Length.	Weight.	Length.	Weight.	Length.	Weight.
Inches.	*Pounds.*	*Inches.*	*Pounds.*	*Inches.*	*Pounds.*	*Inches.*	*Pounds.*	*Inches.*	*Pounds.*
15½	1¼	21¾	2¾	24	3⅛	26¾	5¾	18	1½
21⅝	3¼	22⅛	3¼	24	3¾	26½	3¾	20¾	2¾
21⅝	2⅜	23	3¼	25½	4½	27½	7	21	2½
20⅛	2⅛	23¼	3	25½	5¾	29½	8¾	23⅛	3¼

In this species the basibranchials bear teeth which are generally numerous and large. Occasionally specimens will be found in which the teeth are few and frail or entirely absent. Many examples observed at the Truckee Dam at Thisbe were without exception supplied with basibranchial teeth. At another time 20 individuals examined at the same place produced 6 examples without such teeth. An occasional specimen taken in Pyramid and Winnemucca Lakes had none, the number running about 1 to 10. It here appeared probable that teeth are more often absent in larger individuals, those over 500 millimeters in length, than in the smaller ones. The gillrakers usually number from 23 to 25. The branchiostegals number 10 or 11, often 12, rarely 9.

Number of gillrakers	22	23	24	25	26	27
Number of specimens	9	13	17	3	1	2

Number of branchiostegals	9	10	11	12
Number of specimens	1	30	49	19

There are from 70 to 85 cæca present. There are usually from 153 to 163 scales in the lateral series sometimes as few as 150 or as many as 170; 29 to 39 above the lateral line.

Measurements of a series of specimens are here presented:

LAKE TAHOE NEAR TALLAC, CAL., JUNE 20, 1911.

Length of body.................mm..	325	300	274	318	280	324	305	295	344	310
	♂	♂		♂	♂	♂	♀	♀	♀	♀
Length head	0.26	0.25	0.255	0.27	0.255	0.255	0.255	0.25	0.24	0.24
Depth body	.215	.23	.24	.24	.21	.215	.235	.23	.20	.215
Depth caudal peduncle	.095	.10	.95	.105	.10	.10	.105	.10	.095	.10
Length caudal peduncle	.155	.175	.155	.15	.18	.16	.145	.165	.16	.165
Length snout	.07	.07	.07	.075	.07	.075	.065	.06	.06	.06
Length maxillary	.16	.15	.145	.16	.15	.145	.145	.135	.125	.13
Diameter eye [a]	.45	.04	.045	.04	.04	.038	.04	.04	.037	.04
Interorbital width	.075	.08	.075	.085	.075	.075	.075	.079	.075	.075
Depth head	.16	.17	.16	.18	.16	.16	.16	.155	.15	.16
Snout to occiput	.18	.17	.17	.18	.17	.163	.16	.16	.15	.16
Snout to dorsal	.495	.485	.51	.53	.50	.49	.49	.495	.485	.48
Snout to ventral	.53	.53	.54	.54	.52	.53	.53	.53	.53	.525
Length base of dorsal	.11	.12	.10	.11	.105	.105	.115	.10	.115	.11
Length base of anal	.115	.11	.10	.115	.11	.11	.125	.115	.105	.12
Height dorsal	.13	.145	.125	.13	.14	.12	.135	.135	.125	.135
Height anal	.13	.135	.12	.14	.135	.13	.135	.14	.13	.135
Length pectoral	.17	.19	.18	.17	.165	.16	.17	.165	.16	.17
Length ventral	.14	.14	.13	.135	.14	.125	.125	.13	.125	.13
Length caudal	.21	.22	.215	.22	.225	.20	.20	.20	.20	.20
Dorsal rays	11	11	10	10	10	11	11	10	11	11
Anal rays	11	10	11	12	12	11	12	11	11	12
Pectoral rays	13	14	13	14	14	14	14	14	14	15
Scales lateral series	156	160	170	163	166	162	166	159	169	160
Scales above lateral line	33	33	35	35	32	31	34	32	34	32

PYRAMID LAKE, EAST SIDE, MAY 29, 1911.

Length of body.................mm..	500	462	460	385	460	460	465	443	385	412
	♂	♀	♂	♀	♀	♂	♂	♀	♀	♂
Length head	0.24	0.235	0.26	0.25	0.24	0.242	0.255	0.245	0.245	0.245
Depth body	.205	.205	.20	.215	.20	.178	.20	.195	.21	.21
Depth caudal peduncle	.08	.085	.085	.083	.078	.08	.085	.08	.085	.085
Length caudal peduncle	.165	.165	.155	.175	.155	.155	.165	.16	.165	.17
Length snout	.065	.063	.075	.067	.06	.065	.075	.068	.06	.063
Length maxillary	.136	.13	.15	.135	.135	.135	.135	.155	.14	.14
Diameter eye [a]	.035	.035	.034	.036	.035	.035	.035	.035	.035	.034
Interorbital width	.075	.075	.08	.075	.072	.075	.075	.075	.075	.071
Depth head	.155	.16	.155	.15	.145	.145	.16	.155	.145	.145
Snout to occiput	.16	.15	.17	.165	.145	.16	.165	.155	.16	.155
Snout to dorsal	.51	.49	.505	.51	.505	.50	.495	.505	.50	.50
Snout to ventral	.535	.54	.55	.545	.53	.55	.55	.535	.545	.545
Length base of dorsal	.095	.09	.115	.095	.11	.115	.11	.095	.105	.095
Length base of anal	.115	.104	.12	.10	.12	.105	.10	.11	.105	.095
Height dorsal	.115	.105	.11	.115	.115	.11	.11	.115	.125	.113
Height anal	.115	.12	.12	.115	.12	.12	.12	.125	.125	.11
Length pectoral	.14	.135	.145	.145	.15	.135	.15	.145	.155	.155
Length ventral	.105	.105	.12	.115	.115	.105	.115	.12	.12	.115
Length caudal	.18	.17	.195	.19	.175	.17	.185	.195	.205	.185
Dorsal rays	10	9	10	10	10	10	10	10	10	10
Anal rays	11	10	12	11	11	11	10	11	11	11
Pectoral rays	13	14	14	12	14	14	13	14	14	13
Scales lateral series	156	162	153	150	161	153	154	160	150	161
Scales above lateral line	34	33	35	32	30	29	30	35	31	31

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[a] The eye is measured vertically.

TRUCKEE RIVER AT GOVERNMENT DAM, NEAR THISBE, NEV., MAR. 26, 1911.

Length of body.....mm..	610	595	640	460	425	585	500	483	447	415
	♂	♀	♀	♂	♀	♀	♂	♀	♂	♀
Length head	0.265	0.245	0.24	0.27	0.245	0.245	0.27	0.245	0.26	0.235
Depth body	.215	.20	.21	.225	.195	.20	.225	.20	.20	.195
Depth caudal peduncle	.10	.083	.09	.10	.085	.077	.95	.085	.09	.09
Length caudal peduncle	.155	.165	.155	.16	.175	.155	.16	.162	.155	.16
Length snout	.075	.063	.68	.075	.07	.065	.077	.065	.07	.065
Length maxillary	.16	.13	.14	.15	.14	.14	.165	.138	.155	.13
Diameter eye	.032	.032	.03	.035	.37	.03	.03	.045	.032	.035
Interorbital width	.092	.078	.082	.08	.08	.075	.085	.075	.082	.075
Depth head	.175	.165	.16	.175	.155	.155	.162	.15	.16	.145
Snout to occiput	.17	.165	.15	.17	.16	.16	.172	.152	.16	.155
Snout to dorsal	.54	.52	.54	.51	.49	.49	.532	.515	.49	.52
Snout to ventral	.59	.59	.555	.55	.535	.545	.57	.53	.54	.54
Length base of dorsal	.11	.112	.105	.10	.105	.105	.11	.095	.125	.105
Length base of anal	.11	.125	.113	.105	.11	.105	.115	.11	.125	.11
Height dorsal	.12	.11	.112	.12	.12	.105	.115	.105	.105	.115
Height anal	.13	.13	.115	.13	.118	.107	.13	.12	.12	.13
Length pectoral	.14	.132	.13	.155	.142	.125	.14	.135	.14	.15
Length ventral	.115	.105	.105	.12	.115	.095	.105	.11	.11	.15
Length caudal	.175	.17	.18	.185	.19	.16	.18	.185	.17	.19
Dorsal rays	10	11	12	10	10	11	11	10	11	11
Anal rays	11	12	12	10	10	12	11	11	12	11
Pectoral rays	13	14	15	13	13	14	14	14	15	13
Scales lateral line	162	165	160	158	158	165	161	157	162	158
Scales above lateral series	33	31	32	30	32	....	32	....	32	31

TRUCKEE RIVER AT GOVERNMENT DAM, NEAR THISBE, NEV., APR. 21, 1912.

Length of body.....mm..	465	450	487	438	414	414	495	445	500	467
	♂	♀	♂	♀	♀	♀	♂	♀	♂	♀
Length head	0.265	0.235	0.25	0.24	0.235	0.25	0.26	0.24	0.27	0.24
Depth body	.235	.22	.21	.22	.22	.215	.235	.23	.23	.215
Depth caudal peduncle	.105	.09	.095	.095	.095	.10	.095	.095	.10	.095
Length caudal peduncle	.16	.145	.16	.16	.16	.155	.165	.15	.17	.175
Length snout	.075	.06	.07	.062	.062	.065	.075	.06	.08	.06
Length maxillary	.155	.125	.15	.135	.125	.145	.16	.135	.15	.125
Diameter eye	.035	.035	.034	.035	.033	.035	.03	.035	.032	.033
Interorbital width	.085	.075	.08	.074	.075	.08	.085	.075	.92	.08
Depth head	.175	.15	.16	.155	.15	.155	.17	.16	.17	.15
Snout to occiput	.175	.145	.155	.145	.15	.155	.17	.15	.17	.15
Snout to dorsal	.485	.495	.49	.485	.48	.51	.505	.51	.53	.51
Snout to ventral	.55	.53	.55	.544	.52	.535	.56	.545	.55	.545
Length base of dorsal	.11	.115	.10	.112	.115	.105	.105	.115	.11	.11
Length base of anal	.105	.115	.105	.12	.115	.11	.105	.11	.115	.11
Height dorsal	.12	.103	.11	.125	.115	.115	.112	.115	.115	.112
Height anal	.12	.11	.124	.13	.125	.13	.125	.13	.12	.125
Length pectoral	.155	.12	.14	.142	.14	.155	.142	.145	.142	.15
Length ventral	.12	.105	.115	.12	.11	.125	.12	.115	.118	.115
Length caudal	.19	.175	.18	.21	.185	.185	.18	.18	.18	.182
Dorsal rays	11	10	10	10	10	10	10	10	10	10
Anal rays	10	12	11	12	11	11	11	11	11	11
Pectoral rays	14	14	14	15	14	14	13	14	14	14
Scales lateral line	152	158	157	149	155	157	169	156	156	158
Scales above lateral series	32	31	....	32	34	32	32	32	33	34

In the lakes adults of this species appear to feed largely on minnows, yet many individuals examined at Lake Tahoe had the stomachs fairly stuffed with large black ants. However, these fishes were caught with a spinner, showing that they would even then be attracted by a minnow. In the rivers and creeks insects are eaten whenever they are found. The difficulty of determining the normal food is appreciated when it is seen that the hungry trout is the one most often caught. Of approximately a hundred large trout taken in Pyramid and Winnemucca Lakes only one had the stomach well filled. It contained two large minnows and the partly digested remains of another.

There was not time enough allotted to the present investigation to make any progress in a study of the movements of the lake trout. During a portion of the year these live in deep water and can be caught, if at all, only on long lines. Early in the spring and summer they approach the shore and are taken in relatively shallow water. Juday [a] discusses the movement of this species from shallow to deep water as the season advances. He found no facts in support of theories which had already been offered to account for the migration, but expressed the opinion that several factors were involved.

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[a] Bulletin, Bureau Fisheries, vol. XXVI, 1906, p. 137.

Brief observations at Pyramid Lake seem to indicate that the trout start from deep water (which may possibly be regarded as their normal habitat) on the nuptial migration. Returning later in the season, thin and exhausted, they begin ravenously feeding on the minnows which have then come inshore for spawning purposes. As the emaciated condition of the trout approaches the normal, they gradually retire to the deeper water from which they came earlier in the year. When their hunger becomes satisfied, and fatty tissue has accumulated in the body, it is evidently more difficult to take them with hook and line.

Trolling is the method usually employed by fishermen and anglers in catching trout in the larger lakes. The usual outfit consists of 100 feet of 6-strand No. 27 copper wire, closely twisted. To this is attached sufficient length of heavy hand line so that some may be available in case of fouling. A swivel on the distal end of the line connects an attraction spoon of bright metal measuring about 4 inches. This is followed by a fine wire or gut leader from 1 to 2 feet long, carrying a small spinner with single, double, or triple hook or merely a baited hook of liberal size. The line is trolled deep, jerked at regular intervals, or held in the hand with the moving oar. The captured fish is brought over the side without ceremony or landed with a large scoop net. Often a linen line with large sinker is used. Anglers usually employ more refined methods, light trolling rods being often seen.

Trolling with and without the large attraction spoon, from the same boat and at the same depth, resulted in many more strikes on the line bearing the large spoon. With the spinner, baited hooks seemed to bring better results than the naked ones.

Along the lower courses of the rivers and on the lakes, especially off rocky points where the rapidly shelving bottom brings the deep water near shore, a crude method of bait casting is successfully employed in taking large trout. A bamboo pole from 12 to 20 feet long and very stiff is supplied at regular intervals with large steel guide rings, a tip ring of the same sort is also lashed on, a clear space of about 4 feet is left at the butt, and a long, heavy line is passed outward through the rings and a lead weighing from 2 to 8 ounces is attached. From the lead a 2-foot leader of wire or gut extends to a spinner with single, double, or triple hooks. The latter are used naked or baited. The excess line is either coiled on the ground preparatory to a long cast or wound about the hand for a short one. A rapid side cast sends the lead and its dangling tackle far out over the water. As the lead plunges, the pole is brought to a nearly vertical position, the butt resting against the belt of the fisherman, and the line slowly and steadily brought in, the lure being thus trolled toward the shore. A steady troll is maintained by swinging the pole forward and backward, the forward movement coinciding with the pull on the line. The line is hauled with the left hand and checked by passing it between the fingers of the right. A slight variation from this rig is used by different fishermen, but on the whole it is a heavy, awkward, and unsportsmanlike assemblage of tackle.

On observing this method of fishing it occurred to the writer that light bait-casting equipment might be profitably substituted, and when an opportune time came the experiment was tried and some tackle tested out. Split-bamboo bait-casting rods 5½ feet in length and weighing 4¾ and 5½ ounces, respectively, were provided with an easy-running quadruple reel and light (4 or G) soft braided line of about 200 yards length. Various lures, spinners with naked and baited hooks, and minnows were used. It appeared that a fresh minnow following a small spinner or impaled on an "Archer" was the most successful of all. A trout thus landed weighed 8¾ pounds, and judging from the ease with which it was killed it seemed probable that the very largest might be successfully brought to gaff. This for the clear open water of the lake. In the river where the current is swift, and when a fish is large, a stronger line and possibly a more sturdy rod may be necessary.

Observations from rocky points, where one may see far out and deep in the clear water, showed that the trout often followed the lure for a time before taking it. Sometimes the spoon was closely inspected or nosed and then abandoned. Experiments appeared to demonstrate that when the hooks were baited with worms or pieces of minnows these slow-biting and cautious trout, which are presumably the better-fed and fatter examples, were much more often taken. Occasionally a sharp jerk on the line seemed to end the fishes' indecision.

The light bait-casting equipment is not often seen in the West. However, it would seem from the observations here recorded that it might profitably be employed in many situations and among the mountain lakes at least become a companion if not a rival of the rod and fly. Bait casting for trout seems to be more successful when the water is ruffled by the wind. It should be attempted only when the trout are feeding near shore. Large minnows and an occasional Sacramento sunfish were caught in this way in Pyramid and Winnemucca Lakes.

The large trout seldom rise to the artificial fly except at times in the high Sierras. The same species when living in the rivers and in their rapid and cool tributaries furnish excellent sport for the angler. All recommend small flies, 12 to 16, and not in great variety.[a] Many of the smaller desert streams are so closely lined with dense brush as to make fly fishing quite out of the question. Here the angler should provide himself with a short bait rod, use worms and grasshoppers, and be prepared for a trout weighing 2 or 3 pounds.

Salmo aquilarum, new species. Eagle Lake trout.

The trout of Eagle Lake is allied to the trouts of the western slopes of the Sierras, but is not closely related to the cutthroat of the Lahontan system. It is distinguished by the robust body with a deep caudal peduncle and large and strong fins, the very large and conspicuous adipose fin, the large scales, and the color.

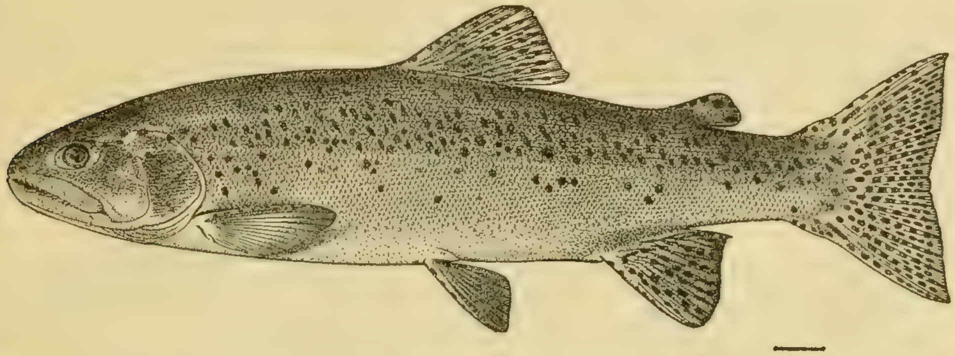

Fig. 7.—*Salmo aquilarum*. Type. Eagle Lake trout.

The following description is of the type 75653, United States National Museum, a male specimen 480 mm. long, taken at Eagle Lake near the mouth of Pine Creek, Cal., May 27, 1913. (See fig. 7.)

Head 4.2 in length to base of caudal; depth 4.2; depth of caudal peduncle 9.8; eye 7.5 in head; interorbital space 3; snout 3.5; maxillary 1.9; height dorsal 6.5 in length; adipose fin 12.5; length caudal 4.8; pectoral 5.6; ventral 7.5; height anal 6.9; scales in lateral series 136.

Body deep, caudal peduncle robust; head rather pointed; maxillary broad and long, extending far beyond posterior border of eye; edge of opercle gradually sloping from above downward and backward to the bluntly rounded point; distance from edge of preopercle to edge of opercle 3.8 in head. Branchiostegals 11. Gillrakers 18, rather thick at the base; pointed at tips, and decidedly sickle-shaped. Vomerine teeth in three series in front, the middle ones extending backward. Teeth of palatines, maxillaries, and mandibles in a single series; glossohyal with teeth; basibranchials without teeth.

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[a] The expressed opinions of some successful anglers may serve as a guide to one who has not fished in the region.

Fred A. Gladding: "From Truckee to near Reno, royal coachman, professor, ginger quill, march brown; from near Reno downstream to near Glendale, gray drake, stone fly, hare's ear, and wren tail; June and July."

George T. Mills: "For eastern slope of the Sierras, alder, pale evening dun, imbrie, bee, fern fly, and blue bottle."

Prof. R. L. Green: "Sierras above Lake Tahoe, Governor Alvord; sometimes change to a fly not often used in the region."

George I. James: "For the Truckee, royal coachman, professor, march brown, white miller, cow dung, ginger quill, blue quill."

Prof. S. B. Doten: "Ginger quill, blue quill, royal coachman, professor, may fly, and red spinner. The may fly is a rubber body, gauze wing."

Dr. W. K. Fisher: "Region above Fallen Leaf Lake, cahil, brown hackle, black gnat, royal coachman, cow dung, march brown."

George G. Schweis: "Truckee, blue quill, pheasant, royal coachman, professor (assorted). Quills most satisfactory, especially during low, clear water when the fish are shy."

Morton's gun store, Reno: "We sell most of royal coachman, ginger quill, blue quill, red spinner, golden spinner, professor, and red ant. Dry flies not generally useful because of turbulent water."

Scales large and deeply embedded; pores in lateral line 120; series of scales above lateral line, counting upward and forward to a point just before dorsal, 29. Scales of nape minute and closely crowded as are those of throat and abdomen. Axillary scales of ventral small, equal in length to vertical diameter of eye; sharply pointed. Dorsal rays, 11; edge of fin concave. Adipose dorsal very large, broad, and thick. Caudal broad and strong, the posterior edge slightly concave, the lower lobe a little longer than the upper. Anal rays 11, edge of fin somewhat concave. Pectorals strong and rather pointed. Ventrals obtusely pointed.

In alcohol the body is dark brownish or olive, somewhat lighter below. There are very few spots on upper part of head; middle of back from occiput to dorsal without spots; upper half of body with large, elongate, sometimes nearly rectilinear spots of somewhat irregular outline, which grow larger posteriorly; dorsal with about 10 rows of oval spots; caudal covered with elongate spots some of which are connected; anal spotted; pectorals with a row of spots along first ray; ventrals immaculate; adipose dorsal with six round spots.

In life the body above and down the sides nearly to the lateral line was a rich dark olive, each scale brassy and showing very conspicuously. Sides from just above the lateral line downward and including the ventral surface deep coppery red with bright metallic reflections. Upper part of head like the body; sides of head cherry red, very rich in color; throat and chin dusky, but with a trace of red beneath the mandibles. Iris brassy. Pectorals dusky, broadly and very conspicuously edged above with olive. In life the spots were similar to those of the preserved specimen, dense black.

A female of exactly the same length is somewhat deeper, and has a smaller head and shorter maxillary. The color is very different. The spots are somewhat larger and more numerous, and they extend downward on the sides far below the lateral line. In life the female was light olive above, each scale being silvery with greenish reflections; sides lighter, the scales reflecting a more intense green, the ventral surface silvery with a pinkish tint. A very indistinct pale reddish lateral stripe extends along the side of body, mostly below the lateral line. A narrow, deep green stripe, two scales wide along the lateral line. Dorsal surface of head like the back. Cheeks and opercles reddish. Iris orange. Dorsals and caudal olive. Pectorals dusky, distinctly edged with olive on the first ray. Ventrals and anal suffused with red and very distinctly edged with the same.

A large school of this species consisting of about 40 individuals of both sexes was observed loitering in the deep channel leading to the mouth of Pine Creek, which was then almost dry (May 27, 1913). Through the clear water they were seen to be remarkably uniform in size and color, the males being easily distinguished by their deep, coppery sides and rich red cheeks. Several dead specimens along the shore were of the same size as those secured.

The flesh of this trout is deep red, very firm and fatty, far superior to that of the Tahoe trout.

It is said that anglers do not succeed in catching trout in Eagle Lake, their failure being attributed to either a scarcity of fish or an abundance of food.

Numbers are killed each year by certain settlers in the neighborhood, who take advantage of the annual spawning migration which occurs early in May, when apparently the entire trout population of the lake attempts to move up Pine Creek, the only tributary. This annual carnage, which of recent years has taken nearly every fish that entered the creek, was indulged in by the Indians long before the whites appeared. If continued by deadly methods recently adopted here, it will surely result in the complete extermination of the species unless perchance a few small individuals succeed in breeding in Pine Creek. In extenuation of this unsportsmanlike and destructive practice the plea is offered that many of these fishes are often stranded and perish on the meadows after a sudden fall in the water of the creek, and that at times large numbers never reach the spawning grounds, and also that numbers fail to return to the lake.

MEASUREMENTS OF SALMO AQUILARUM, EAGLE LAKE, CAL.

Length of body.....mm..	437	443	478	466	Length of body.....mm..	437	443	478	466
	♂	♀	♀	♀		♂	♀	♀	♀
Length head	0.24	0.225	0.22	0.225	Length base of anal	0.115	0.11	0.10	0.10
Depth body	.24	.245	.225	.235	Height dorsal	.14	.13	.14	.14
Depth caudal peduncle	.105	.10	.095	.095	Height anal	.145	.14	.145	.145
Length caudal peduncle	.175	.185	.18	.165	Length pectoral	.18	.17	.16	.175
Length snout	.073	.055	.055	.055	Length ventral	.135	.135	.125	.135
Length maxillary	.135	.105	.105	.112	Length caudal	.19	.195	.17	.18
Diameter eye	.035	.032	.032	.035					
Interorbital width	.085	.075	.07	.07	Dorsal rays	11	10	11	10
Depth head	.16	.15	.145	.15	Anal rays	11	10	10	10
Snout to occiput	.15	.14	.13	.13	Gillrakers	18	16	18	19
Snout to dorsal	.49	.485	.475	.485	Scales lateral series	136	140	139	137
Snout to ventral	.53	.52	.535	.53	Scales above lateral line	29	31	32	32
Length base of dorsal	.12	.115	.12	.115	Branchiostegals	11	11	10	11

Salmo regalis Snyder. Royal silver trout.

Anglers' reports of the presence of a peculiar trout in Tahoe and Pyramid Lakes, with more or less accurate descriptions of one which seemed to differ from the more common Tahoe trout, led to the discovery of this species. By the local fishermen this trout is known as the greenback or grayback. It is distinguished by the absence of spots, by the blue or green dorsal surface, the silvery sides and white belly, and the loose scales which, when the fish is caught, adhere to the fingers like bits of foil.

A careful examination of many trout from Lake Tahoe and the questioning of anglers and market fishermen brought no more important results than the finding (June 20, 1911) by Mr. G. E. West of a 10½-inch king salmon, *O. tschawytscha*, apparently the first to be observed of some that had been introduced.

Later, specimens were secured by Messrs. Ralph Lowe and W. P. Lyon, of San Jose, and F. K. Pomeroy, of Palo Alto. These were caught in deep water near Brockway, on the east side of Lake Tahoe, and served as a basis for the description [a] of the species.

S. regalis is distinguished from *S. henshawi* by color and in having a shorter head, a shorter and more rounded snout, a smaller maxillary, larger scales, narrower and more pointed fins, perfectly smooth basibranchials which are without teeth, and fewer gillrakers. A fresh specimen is of a beautiful deep steel blue on the dorsal surface, which in some lights is seen to be shaded with olive, the blue extending downward on the sides to about the sixth row of scales above the lateral line, where it abruptly gives place to the most brilliant and highly burnished silver. The silver dulls ventrally, the chin, throat, and abdomen being dead white. No dark spots appear except on the dorsal and caudal fins, where they are inconspicuous. No red or yellow color is found anywhere except on the cheek, where it glows faintly through the silver. After a specimen has been preserved in alcohol, small spots appear on the dorsal and caudal fins and a few poorly defined ones on the dorsal part of the body.

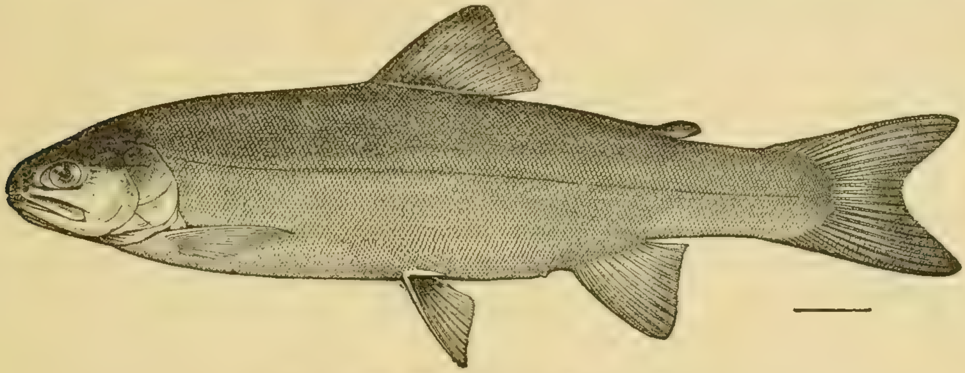

FIG. 8.—*Salmo regalis*. Type. Royal silver trout.

From the specimens examined (four in all) there seems to be from 144 to 150 lateral series of scales, 29 to 31 above the lateral line, 11 to 13 branchiostegals, and 19 to 21 gillrakers. No external sex differences were observed.

The market fishermen and most of the anglers who visit Lake Tahoe confuse examples of this species with silvery individuals of *S. henshawi*, and as it is next to impossible to get taintless information regarding *S. regalis*, almost nothing definitely is known of its habits. It seems to be very rare, or at least specimens are seldom caught. It does not appear to enter the creeks which are tributary to the lake, and its time of spawning is unknown.

An examination of the stomach contents revealed the remains of many small insects—ants, bugs, beetles, etc.—which usually may be seen floating on the surface of tributary streams and are carried out into the lake. This would indicate surface feeding, which may possibly occur at night. As this trout may be taken with a spinner, it may be inferred that it also feeds upon minnows.

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[a] Bulletin, Bureau Fisheries, vol. XXXII, 1912, p. 25.

It seems probable that the relationships of *S. regalis* and also of *S. smaragdus*, a representative species found in Pyramid Lake, are with *S. irideus* of the western slopes of the Sierras, *S. smaragdus* having apparently departed farther from the parent form than has *S. regalis*.

Salmo smaragdus, new species. Emerald trout.

The trout here described for the first time is a native of Pyramid and Winnemucca Lakes and does not seem to occur elsewhere. It is apparently a representative of *S. regalis* of Lake Tahoe, and in common with that form it is characterized by its peculiar color, remarkably different from that of other species of the region. The upper parts of the head and body are deep emerald green, with a few small, evanescent, dark spots scattered here and there, the sides of polished silver, and the ventral surface dead white. The body is long and slender, the head rather short and rounded, eyes large, maxillary weak, basibranchials without teeth, gillrakers few, slender and sharp, the scales large and very loosely attached, and the fins thin and pointed, the entire appearance of the fish suggesting the depths of the lake as its habitat rather than the river or the mountain torrent. From *S. regalis* this species differs in being green above instead of blue, in having larger scales (there being 124 lateral series—144 to 153 in *S. regalis*), a more slender body, longer and more pointed snout, and a gill cover distinctly different in shape, the upper or opercular part presenting a rounded, broad shoulder, while the posterior margin is relatively truncate.

The species is recognized by the older Piute Indians. To them it is *the* trout, "A-gaih," in contradistinction to "Tomoo-agaih" or the winter trout, the large migrants of *S. henshawi* which appear in the lower Truckee River early in winter, and the "Tama-agaih" or spring trout ("tommy" of the anglers), a smaller fish, also *S. henshawi*, though of a later run. It is also familiar to the more experienced fishermen of Pyramid and Winnemucca Lakes, who call it the "green-back."[a] By them it is distinguished by its more slender form, the brilliant silver of the sides, the unparalleled green of the dorsal surface, the frail, broad, thin scales which adhere to the fingers like bits of foil, the firm, deep-red flesh, and also by the unusually strong and characteristic fight which ensues after the fish has been hooked. Their description of this trout led indirectly to the discovery of *S. regalis* in Lake Tahoe. It is said by all to be extremely rare, so that the most persistent fisherman sees but one or two during a season. It may possibly escape notice in the hands of some anglers where it is confused with small, silvery examples of the more common cutthroat trout, although even the less observant will immediately recognize the difference when attention is called to the specific characters. But whether or not the species is rare, the fact remains that while in the past countless numbers of large trout have been shipped from the lakes, many even reaching the markets of San Francisco, this form with its strongly marked external characters, and very desirable food qualities, has escaped the notice of naturalists and the serious attention of anglers and others interested in fishes.

Description of type no. 75596, United States National Museum, a specimen measuring 480 mm. in length, from Pyramid Lake, Nev., May 22, 1913. Sex, male. (See fig. 9.)

Head 4.5 in length to base of caudal; depth 5; depth caudal peduncle 10.5; snout 3.8 in head; vertical diameter of eye 5.6; length maxillary 1.9; dorsal rays 11; anal 11; scales in lateral series 124; above lateral line 26; between lateral line and base of ventral 23; between occiput and dorsal about 70.

Body slender, the head and snout elongate when compared with *S. regalis*. Maxillary comparatively broad, rather thin and weak, not extending far beyond orbit. Gill cover obtusely rounded behind; the opercle wide and with the upper edge broadly rounded, imparting to the gill cover a pronounced and characteristic shoulder. Branchiostegals 11. Gillrakers 9–11, long and acutely pointed. Vomerine teeth in 2 distinct rows, the toothed area somewhat longer than in *S. henshawi*. Strong teeth on anterior part of tongue; none on basibranchials; edge of maxillary except extreme posterior part with teeth.

Scales notably large and loosely embedded; those immediately behind occiput and on ventral surface minute. Fins naked. Lateral line with 123 pores, slightly decurved beyond its origin, and then straight to middle of caudal.

Longest (first) dorsal rays contained 1.8 times in head; pectoral 1.6; pectorals and ventrals acutely pointed; ventral inserted on a vertical through base of third dorsal ray. Caudal deeply forked, the lobes pointed. Adipose fin small and rather narrow.

---

[a] The name "green-back" is not available, as it has been applied elsewhere as a common name for a particular trout, therefore "emerald trout" is suggested as an appropriate substitute.

In the preserved specimen the dorsal surface including the upper third of body is jet black, no spots being visible; sides silvery, with greenish and yellowish reflections; ventral surface white; dorsal fin with about 10 rows of very small, elongate, black spots. Adipose fin with 4 round spots. Caudal with small, elliptical spots arranged along the rays. In life the upper surface including the head and snout was deep emerald green, yellowish reflections appearing in some lights, and scattered dark spots occurring here and there from the occiput to the tail; sides silvery, the metallic color extending almost to the tip of caudal fin; lower surface dead white. There is no red or pink on any part of the body or fins.

The following proportional measurements are recorded in hundredths of the length to base of caudal: Length head 0.225; depth body 0.2; depth caudal peduncle 0.095; length caudal peduncle 0.18; length snout 0.065; length maxillary 0.115; diameter eye 0.04; interorbital width 0.075; depth head 0.15; snout to occiput 0.14; snout to dorsal 0.475; to ventral 0.505; length base of dorsal 0.12; of anal 0.1; height dorsal 0.125; height anal 0.12; length pectoral 0.15; length ventral 0.125; length caudal 0.21.

The specimen here described was caught by the writer shortly after sundown, while trolling with rather heavy tackle at a depth of about 40 feet below the surface. On being brought near the boat the fish left the water twice in spite of its heavy impediments, in strong contrast to the behavior of the more sluggish cutthroat, which even with light tackle may sometimes be brought to gaff without breaking the surface. The immediate region of its capture and the water near by were carefully worked over for a considerable time without success. That it was taken with a spinner demonstrates that it feeds, at least at times, on minnows. The stomach contained parts of a small minnow together with the remains of insects (beetles and bugs); but whether the latter had been taken directly or as part of the captured fish could not be determined.

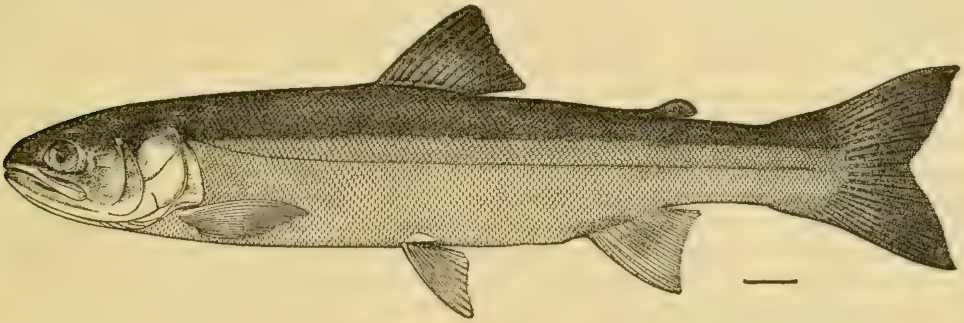

FIG. 9.—*Salmo smaragdus.* Type. Emerald trout.

Little is known of the habits of this species. It is said to be more frequently taken in the northern parts of the lakes, far from the inlets. It is not known to enter the river, and consequently it is supposed to spawn in the lake.

It will be noted that both this and the preceding species are indigenous to the same basin. None the less they may be regarded as particularly good examples of species which differentiated through the agencies accompanying isolation. For although Lake Tahoe, the habitat of *S. regalis*, and Pyramid Lake are connected by the Truckee River, which has its origin in the former and flows into the latter, they are in effect separated by what to some species is an impassable barrier rather than an open channel, the turbulent waters of the river plunging down 2,300 feet over a bowlder-strewn bed but little more than a hundred miles in length. Along with isolation the species are subjected to very different environmental conditions. The water of Lake Tahoe comes almost immediately from melting snow and is unusually pure and fresh, while that of the lower lake into which it finally flows is so charged with various salts that no arborescent vegetation grows on the shores.

Cottus beldingi Eigenmann. Desert rifflefish.

Cottus beldingi is closely related to *C. gulosus*, *C. punctulatus*, and the doubtful form *C. klamathensis*, differing from the first and last in having fewer rays in the anal fin and from *C. punctulatus* in the weaker armature of the preopercle. Like the latter, *C. beldingi* has a smooth skin and usually a narrow band of palatine teeth. The four forms here enumerated resemble each other very closely and their separation is at times a matter of some difficulty. Distributed through the Sacramento, Klamath, Columbia, Oregon Lake, and Lahontan systems, they may be regarded as representatives of a single ancestral form. Rutter has recorded *C. beldingi* from Cole Creek near Sierraville, "a Truckee Basin species with entirely smooth skin, no palatine teeth, and short fins." The difficulty of distinguishing between *C. beldingi* and *C. gulosus* compels one to accept this identification with reserve. Examples of *C. gulosus* often appear with perfectly smooth skin, no palatine teeth, and comparatively short fins. The writer has not observed *C. beldingi* with prickles, but palatine teeth are frequently present, and the fins are usually longer than those of *C. gulosus*.[a]

Like *C. gulosus*, *C. beldingi* has a large and well-rounded head and a deep robust body with a large caudal peduncle. The skin appears to always be free from prickles. The lateral line is imperfect, usually reaching a point below posterior third of the soft dorsal, scattered pores sometimes appearing on the caudal peduncle. Palatine teeth are absent, or in some cases present when there is a narrow band equal in length to about half the longitudinal diameter of eye. The maxillary reaches posteriorly to below edge of pupil or even to center of eye. The nostrils have distinct and well-elevated rims, that of the anterior being the higher. There is always one prominent, sharp, flat, upturned, preopercular spine and usually a second small one below it which projects downward. The spinous dorsal is broadly rounded in outline, the edge scarcely scalloped, entirely separated from the soft dorsal in some examples, meeting it in others, or even joining it, the membrane then extending a short distance upward on the base of the first ray. The edge of the soft dorsal is but little scalloped. The last ray is connected with the caudal peduncle with a narrow membrane. Edge of anal deeply scalloped, the last ray without a posterior membrane. Pectoral rays usually 14 or 15, their tips often extending to a point above second or third anal ray, sometimes barely reaching origin of anal, but averaging longer than those of *C. gulosus*. Ventrals 1, 4, sometimes 1, 3. Caudal bluntly rounded. The dorsal spines number from 6 to 8; rays 15 to 18; anal rays 11 to 13.

The sides and upper part of the body are irregularly banded or clouded with dusky, coarsely and profusely spotted, or in some cases reticulated. When more or less definite bands appear, there are usually two beneath the spinous dorsal and three beneath the soft dorsal. There is almost invariably a narrow and sharply defined band at the base of caudal. The spinous dorsal is more or less clouded with dusky pigment. The soft dorsal, anal, and caudal rays bear at intervals elongate black spots, which arrange themselves in lines, the fins thus presenting a barred effect. Often the anal is immaculate, and in some cases the dorsal is nearly so. The pectoral is frequently barred. The head is dark, with closely apposed dusky clouds, reticulations, and spots. In life the color is light or dark olive, some examples being rather grayish.

On account of the roily condition of the streams when most of the observations in the Lahontan system were made, specimens of this species were seldom seen until they became entangled in the net. Several were secured with hook and line. None was caught in the lower course of the Truckee River. Examples were most often taken while dragging the net over rough bottom in the more rapid parts of the stream. In the Truckee River near Floriston an individual was occasionally seen either under a bowlder or close by its sheltering edge. The partly digested body of a young sucker was found in the stomach of one specimen.

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[a] Rutter also described two new Cottoids from the Sacramento, *C. macrops* and *C. asperrima* (Bulletin) Bureau Fisheries. vol. XXVII, 1907, p. 144 and 146). The writer has made a careful examination of the types of both of these which are preserved in the National Museum. The type of *C. macrops* on direct comparison with examples of *C. gulosus* seems to differ in no way from a typical example of that species, except that the eye is somewhat larger. In the figure the eye is represented as directed laterally, while in specimens it is directed obliquely upward. The type of *C. asperrima* appears also to be a specimen of *C. gulosus*, having the same general characteristics of that species, except that the prickly investment of the skin is much more marked than usual, but not more extensive than has been observed in other specimens. There are seven dorsal spines in the type. The eyes are directed more laterally, the back is somewhat more elevated, the caudal peduncle is more slender, and the dorsal fins are more broadly united than the figure would lead one to suppose. *Cottus gulosus* is a species of wide range and variable characteristics, able to enter the brackish water in the mouths of the rivers and also make its way high up in the smaller mountain tributaries. It has been described under several names ,and at times has been confused with *C. asper* and *C. aleuticus*.

MEASUREMENTS OF COTTUS BELDINGI.

	Humboldt River, Carlin.					Humboldt River, Palisade.					Carson River, Gardnerville.						
Length of body.......mm.	65	62	55	55	56	62	65	58	75	55	80	81	69	76	68	64	52
Length head	0.34	0.34	0.35	0.35	0.34	0.32	0.34	0.36	0.37	0.35	0.30	0.33	0.31	0.31	0.30	0.31	0.31
Depth body	.28	.24	.26	.25	.25	.24	.22	.26	.26	.24	.21	.23	.21	.21	.21	.21	.23
Depth caudal peduncle	.08	.09	.095	.09	.09	.095	.08	.095	.095	.09	.08	.10	.09	.08	.09	.09	.09
Length caudal peduncle	.15	.15	.16	.18	.18	.15	.15	.15	.15	.16	.18	.16	.15	.17	.18	.16	.19
Length snout	.11	.12	.12	.12	.11	.10	.11	.12	.12	.11	.10	.12	.10	.10	.10	.10	.095
Length maxillary	.16	.16	.15	.15	.16	.15	.16	.16	.18	.16	.17	.19	.15	.15	.145	.14	.13
Diameter eye	.08	.09	.07	.07	.08	.075	.07	.06	.08	.075	.10	.07	.08	.07	.065	.08	.07
Interorbital width	.05	.05	.05	.045	.04	.05	.05	.045	.05	.05	.05	.04	.04	.04	.04	.04	.05
Depth head	.21	.20	.20	.21	.20	.19	.20	.20	.21	.19	.19	.23	.19	.20	.21	.20	.185
Snout to dorsal	.41	.39	.37	.38	.37	.37	.36	.39	.40	.37	.35	.38	.35	.35	.34	.35	.34
Length base of spinous dorsal	.23	.22	.22	.20	.21	.22	.23	.21	.24	.21	.23	.21	.22	.22	.22	.22	.21
Length base of soft dorsal	.39	.42	.39	.39	.38	.40	.36	.37	.38	.40	.37	.35	.38	.39	.36	.38	.38
Length base of anal	.29	.32	.28	.27	.28	.29	.29	.30	.27	.31	.25	.28	.29	.27	.28	.28	.29
Height spinous dorsal	.11	.10	.10	.11	.10	.10	.11	.11	.09	.105	.10	.10	.10	.10	.10	.09	.09
Height soft dorsal	.16	.16	.15	.14	.15	.15	.17	.15	.16	.17	.12	.13	.15	.13	.13	.14	.14
Height anal	.20	.18	.17	.16	.17	.21	.20	.18	.19	.20	.14	.19	.15	.14	.15	.13	.15
Length pectoral	.31	.32	.33	.34	.34	.33	.29	.32	.31	.32	.29	.29	.31	.29	.28	.30	.31
Length ventral	.22	.23	.23	.21	.24	.22	.22	.205	.21	.22	.19	.19	.20	.18	.19	.20	.21
Length caudal	.25	.26	.26	.26	.25	.25	.25	.26	.25	.27	.22	.23	.24	.22	.23	.24	.25
Dorsal spines	7	7	8	7	7	7	8	7	7	7	8	7	7	7	7	7	7
Dorsal rays	17	17	16	16	16	17	17	16	15	16	16	17	17	16	17	17	17
Anal rays	13	13	11	11	12	12	11	11	11	13	11	12	12	12	12	12	12
Pectoral rays	15	15	14	14	14	15	15	14	14	13	14	15	14	14	15	14	14

	Dorsal fin.							Anal fin.		
	Spines.			Rays.				Rays.		
Number	6	7	8	15	16	17	18	11	12	13
Specimens from—										
Carson River	....	22	18	....	8	19	3	6	20	4
Lake Tahoe	1	8	4	....	4	6	3	1	9	3
Star Creek	....	2	4	2	3	1	....	2	4	....
Humboldt River	....	5	4	....	4	4	1	2	6	1

LOCALITIES WHERE SPECIMENS OF NATIVE SPECIES WERE COLLECTED.

Locality	Catostomus tahoensis Gill and Jordan.	Catostomus arenarius new species.	Pantosteus lahontan Rutter.	Chasmistes cujus Cope.	Richardsonius egregius (Girard).	Richardsonius microdon new species.	Siphateles obesus (Girard).	Leucidius pectinifer new species.	Agosia robusta Rutter.	Coregonus williamsoni Girard.	Salmo henshawi Gill and Jordan.	Salmo aquilarum new species.	Salmo regalis Snyder.	Salmo smaragdus new species.	Cottus beldingi Eigenmann.
Truckee Basin:															
Fallen Leaf Lake					×		×		×		×				×
Fallen Leaf Creek	×	×	×		×		×		×	×	×				×
Lake Tahoe near Tallac	×				×		×		×		×				
Cascade Creek											×				
Lake Tahoe near Brockway	×				×		×				×				
Lake Tahoe near Tahoe City	×				×	×	×	×	×		×				×
Lake Tahoe										×					
Truckee River near Tahoe City	×				×						×				×
Truckee River near Truckee					×					×	×				×
Donner Lake	×				×		×				×				×
Little Truckee River			×		×				×		×				×
Truckee River near Floriston										×	×				×
Truckee River near Reno	×		×		×						×				
Truckee River near Derby	×			×	×						×				
Truckee River near Wadsworth	×			×	×		×				×				
Truckee River near Nixon	×	×	×	×	×		×			×	×				
Truckee River near mouth				×			×				×				
Winnemucca Slough	×			×			×				×				
Pyramid Lake	×	×		×			×	×			×				
Winnemucca Lake	×				×		×	×			×				
Washoe Lake							×	×							
Susan River Basin:															
Long Valley Creek	×		×				×		×		×				
Susan River near Susanville			×		×		×		×		×				
Susan River near Snyder's mill	×		×		×		×								×
Susan River near mouth	×				×		×								×
Gold Run	×								×						
Quinn River Basin:															
Quinn River, Fort McDermitt	×		×		×		×		×		×				×
Willow Creek											×				
Humboldt River Basin:															
Star Creek near Deeth	×	×			×		×		×		×				×
Marys Creek near Deeth	×		×		×		×		×		×				
Pine Creek near Palisade	×	×			×		×		×		×				×
Humboldt River near Palisade	×		×		×		×		×		×				×
Humboldt River, Carlin	×	×	×		×		×				×				×
Humboldt River, Winnemucca	×						×								
Little Humboldt River, Winnemucca	×		×		×		×								
Carson River Basin:															
Markleeville Creek, Markleeville											×				
West Carson, Woodford's											×				
East Carson, Gardnerville	×		×		×				×						×
Carson River, Genoa	×		×		×					×	×				×
Carson River near Carson City	×				×										
Walker River Basin:															
West Walker River near Topaz	×				×				×	×	×				×
West Walker River, Hudson	×		×		×				×	×	×				
East Walker River, Bridgeport									×		×				
Walker River, Yerrington	×				×		×				×				×
Walker River, Schurz	×		×		×				×						
Walker River near mouth	×				×										
Walker Lake							×								
Eagle Lake Basin:															
Eagle Lake	×						×	×	×			×			
Pine Creek near Eagle Lake												×			

INTRODUCED SPECIES.

From time to time fishes from other regions have been introduced into the rivers and lakes of the Lahontan system. This has usually been done without any serious study of local conditions which might affect the introduced form or of any consideration of the relations which might arise between introduced and native species. Among the introduced species most of the following seem to have established themselves, some, especially the carp and possibly the Mackinaw trout, to the detriment of more valuable fishes. Black bass are said to reach a large size in Eagle Lake and in Humboldt River. None was seen by the writer. "Black bass" from Walker Lake proved to be Sacramento perch.

Ameiurus nebulosus (Le Sueur). Catfish.

Catfish of this and possibly other species thrive in the broad, quiet waters of the lower valleys. Examples of moderate size may be caught with hook and line in the Truckee, Humboldt, Carson, and Susan Rivers.

Cyprinus carpio Linnæus. Carp.

Carp are widely distributed, and in suitable places they reach a large size. At present they are of no economic importance and are generally regarded as a nuisance.

Oncorhynchus kisutch (Walbaum). Silver salmon.

Mr Mills, of the Nevada Fish Commission, placed a large number of small silver salmon in the lower Truckee River June 27, 1913.

Oncorhynchus tschawytscha (Walbaum). King salmon.

An example of this species 10½ inches long was caught by an angler while trolling in Lake Tallac June 20, 1911.

Salmo irideus shasta (Jordan). McCloud River trout.

This species, known locally as rainbow trout or Shasta trout, seems to be increasing in numbers. Other forms of the rainbow trout may have been introduced at various times, but records are not available. It thrives in the rivers and lakes, where the native cutthroat appears to give way before it. Large specimens were seen in the lower Truckee River and in the Humboldt and Carson Rivers. Examples were collected in Honey Lake Basin and also in Walker River. Specimens found in the desert streams are very light in color. One from Carson River at Genoa was pale olive on the upper surface down to where a pink lateral stripe occurred on the side, which extended from the upper edge of the opercle to base of caudal. Below the stripe the body was silvery, suffused with pale pink. Pectorals, ventrals, and anal bright salmon pink. Dorsal and adipose fins like the back. Some individuals were lighter and more silvery. Black spots were numerous above the lateral line in all the above. An example measuring 18 inches was caught in the Truckee River near the Indian Agency. Above the lateral line the body was profusely spotted, and the general color was darker than that just described. The scales numbered about 140.

In the Nevada hatchery this and the native species have been crossed, and the hybrids have been turned into various streams, but the writer is not aware that any further attention has been paid to the experiment.

Salmo fario Linnæus. European trout; German trout; Loch Leven trout; brown trout.

Specimens of European trout were seen at Tallac. They were caught in Lake Tahoe, Fallen Leaf, and other lakes, and in the Truckee River.

Cristivomer namaycush (Walbaum). Mackinaw trout.

Specimens of this long-headed, ravenous-looking trout were frequently seen at Tallac. It is found in Fallen Leaf, Cascade, and other smaller lakes as well as Lake Tahoe, and it is generally regarded as inferior to both the rainbow and the cutthroat trout. It is difficult to say anything in defense of the introduction of the species. Mr. Mills reports one weighing 26 pounds.

Salvelinus fontinalia (Mitchill). Brook trout.

The eastern brook trout has been introduced, and found a place in the small brush-lined tributaries of the larger streams and lakes where examples of considerable size are frequently caught. Judging from descriptions in eastern publications, it appears to retain its brilliant color and characteristic habits here.

Archoplites interruptus (Girard). Sacramento perch.

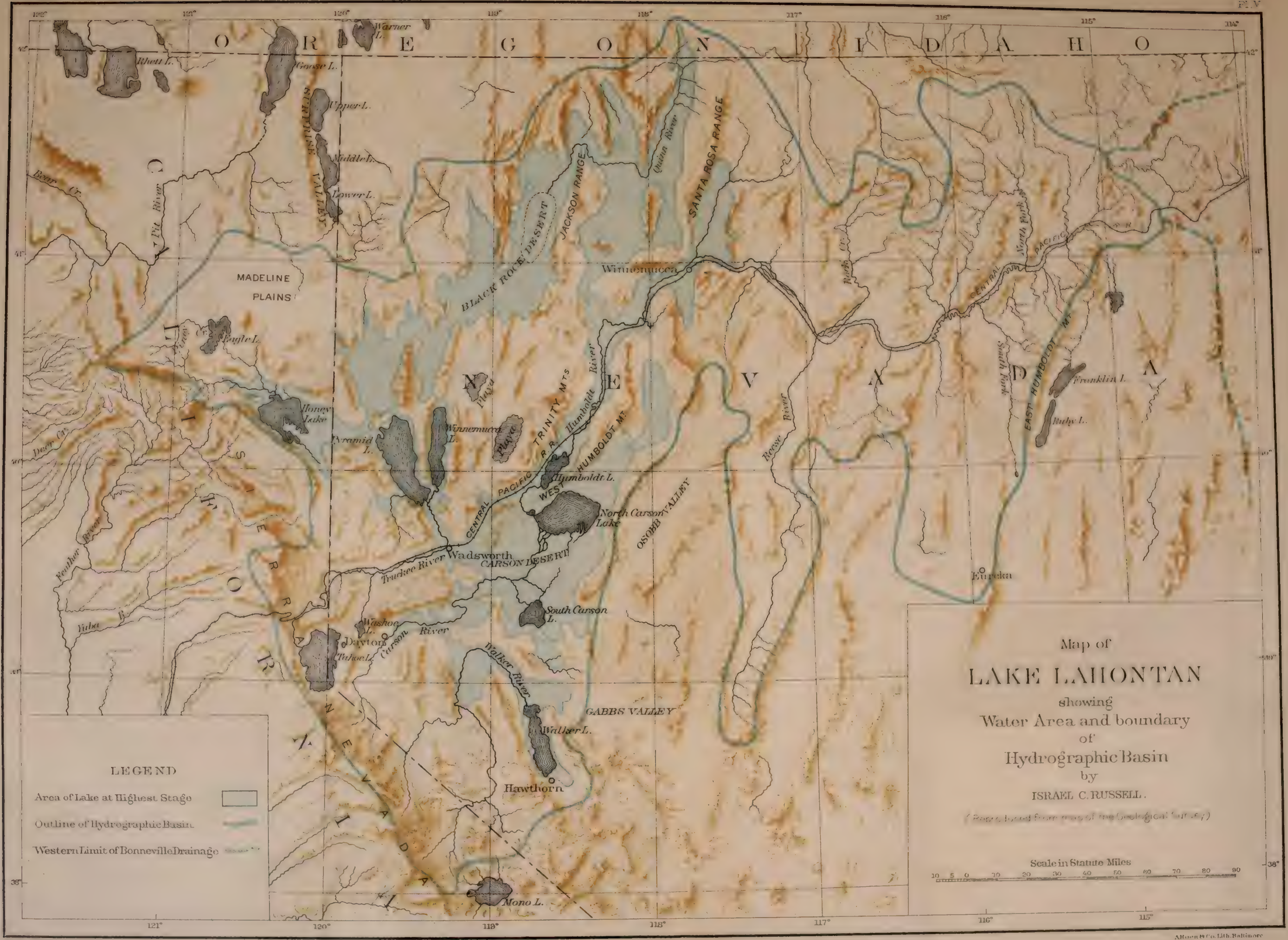
The Sacramento perch is locally known as perch, sunfish, and bass. It is found in the lower courses of the larger desert streams and in Walker, Pyramid, and Winnemucca Lakes. It reaches a large size, an angler reported one which weighed 5 pounds. It may be taken in numbers after the weather grows warm, in the latter part of May or early in June, by trolling or with a light bait-casting outfit. Specimens are attracted by small minnows or spinners with naked or baited hooks. The following measurements and weights are from specimens caught in Winnemucca Lake:

Length.	Depth.	Head.	Weight.	Sex.
Inches.	*Inches.*	*Inches.*	*Pounds.*	
13¾	5⅛	4¼	2	♀
14¼	5¼	4¼	2¼	♀
13⅜	5¼	4¼	2¼	♀
13⅜	4¾	4	1¾	♀
11	4¼	3½	1⅛	♂

Large eggs were found in specimens taken from Pyramid and Winnemucca Lakes May 11, May 22, June 4, and June 7.

Lepomis pallidus (Mitchill). Bluegill.

Specimens measuring 4¾ to 6¾ inches were caught in Susan Creek, July 13, 1911. The species is said to have been introduced in October, 1908.



Map of

LAKE LAHONTAN

showing

Water Area and boundary

of

Hydrographic Basin

by

ISRAEL C. RUSSELL.

(Reproduced from map of the Geological Survey)

LEGEND

Area of Lake at Highest Stage

Outline of Hydrographic Basin

Western Limit of Bonneville Drainage

O R E G O N
I D A H O
C A L I F O R N I A
N E V A D A
S I E R R A N E V A D A
Warner L.
Rhett L.
Goose L.
Upper L.
Middle L.
Lower L.
SURPRISE VALLEY
Bear Cr.
Pit River
MADELINE PLAINS
Eagle L.
Honey Lake
Deer Cr.
Feather River
Yuba R.
Pyramid L.
Winnemucca L.
Playa
BLACK ROCK DESERT
JACKSON RANGE
Quinn River
SANTA ROSA RANGE
Winnemucca
TRINITY MTS
Humboldt River
WEST HUMBOLDT MT.
Humboldt L.
CENTRAL PACIFIC R.R.
North Carson Lake
OSOBB VALLEY
Wadsworth
Truckee River
CARSON DESERT
South Carson L.
Washoe L.
Dayton
Tahoe L.
Carson River
Walker River
Walker L.
GABBS VALLEY
Hawthorn
Mono L.
Reese River
Eureka
Rock Cr.
North Fork
South Fork
EAST HUMBOLDT MT.
Franklin L.
Ruby L.
Scale in Statute Miles
10 5 0 10 20 30 40 50 60 70 80 90
42°
41°
40°
39°
38°
121°
120°
119°
118°
117°
116°
115°
114°

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NOTES ON THE EMBRYOLOGY AND LARVAL DEVELOPMENT OF TWELVE TELEOSTEAN FISHES

⁂

By Albert Kuntz, Ph. D.
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and
Lewis Radcliffe
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⁂

Contribution from the United States Fisheries Biological Station, Woods Hole, Mass.

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NOTES ON THE EMBRYOLOGY AND LARVAL DEVELOPMENT OF TWELVE TELEOSTEAN FISHES.

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INTRODUCTION.

Adequate measures for conservation of our fishery resources and the production of the maximum quantity of food with the minimum of expenditure through proper propagation methods require as their basis a reasonably complete knowledge of the life histories and habits of the fishes. The first step in this direction is the determination of the character of the eggs and young, so that they may be recognized at any stage of development. Many of our important marine food fishes—e. g., cod, haddock, hake, mackerel, and halibut—have floating eggs, which may be collected with an ordinary tow net with much less effort than is required to locate and capture the spawning fish. Thus this knowledge may serve to locate the spawning grounds and also the schools of spawning fish. The immediate value of knowledge of this character has been well illustrated by Dr. Hjort, of Norway. Knowing the character of cod eggs, he applied this method to the coast banks off northern Norway and thereby "succeeded in finding enormous shoals of cod on certain banks where no fishing was carried on, and where, as a consequence of our discovery, millions of cod were afterwards taken."

The present paper embodies the results of a study of the embryology and larval development of teleostean fishes taken in the region of Woods Hole, Mass., during July and August, 1915.

The majority of the species, especially the more important ones, common to this region spawn earlier in the season. Little is known of the breeding habits of the bonito (*Sarda sarda*), the menhaden (*Brevoortia tyrannus*), the butterfish (*Poronotus triacanthus*), and the hake (*Urophycis chuss*). Females of these species in which the eggs were nearly or quite mature and males from which the milt flowed freely were taken. However, all attempts at artificial fertilization failed. The eggs of the bonito and the hake were never taken in the plankton. With the exception of the menhaden, butterfish, and whiting, the eggs of all the species described herein were artificially fertilized and hatched in the laboratory. The eggs of the whiting were artificially fertilized, but all died during early cleavage. Both eggs and young of all the species with pelagic eggs were taken in the plankton.

The embryology and early larval life of several species included in this paper were early studied by Agassiz[a] and Agassiz and Whitman.[b] The embryology of one species, viz, *Tautogolabrus adspersus*, is described and illustrated in great detail by these authors in their fundamental work on the development of osseous fishes.[b] Their observations on other species included in this paper are more or less fragmentary. The pelagic eggs and larvæ identified by them as *Cottus grœnlandicus* are doubtless *Prionotus carolinus*, as a comparison of their figures with the figures here presented of the eggs and larvæ of the latter species will show. The eggs and larvæ described by them as species allied to *Motella* are probably eggs and larvæ of the butterfish. Eggs apparently identical with the eggs described by them as those of the Sienna flounder were taken throughout July and August. They were taken in greatest abundance off Gay Head on August 24. These eggs were not identified by the present writers. Observations on the early development of one species (*Apeltes quadracus*) included in this paper are recorded by Ryder.[c]

The observations recorded herein were made almost exclusively on living material. It is not the purpose of this paper to discuss in detail the embryological development of each species studied, but rather by means of illustrations and descriptions to afford a ready means of identifying eggs or larval fishes at any time during embryonic or larval life. With this purpose in view, the inclusion of several species upon which more or less complete observations have been previously recorded seems justifiable.

Acknowledgments are due Homer Wheelon for the preparation of the majority of the illustrations and general assistance in the investigation and Vinal N. Edwards for assiduous collecting of material.

KEY TO EGGS OF CERTAIN FISHES.

As an aid to the identification of eggs which may be met with in the Woods Hole region during July and August, the following key is appended:

I. PELAGIC EGGS.
  a. Eggs without oil globules.
    b. Eggs spherical.
      c. Egg 0.75 to 0.85 mm. in diameter, highly transparent; pigmentation appears in embryos of 10 to 15 somites in form of small black chromatophores distributed over dorsal surface. *Tautogolabrus adspersus* (cunner).
      cc. Egg 0.9 to 1 mm. in diameter; in all other respects egg and pigmentation of developing embryo resemble preceding..*Tautoga onitis* (tautog).
    bb. Eggs ellipsoidal, yolk cortex segmented.
      d. Major axis but little longer than minor axis, 0.65 to 0.75 mm. long, minor axis 0.1 to 0.3 mm. less..*Anchovia mitchilli* (anchovy).
      dd. Major axis considerably longer than minor axis.
        e. Major axis 1.15 to 1.25 mm. and minor axis 0.55 to 0.8 mm. in length; developing embryo within egg unpigmented............................*Anchovia argyrophana* (anchovy).
        ee. Major axis 1.2 to 1.5 mm. and minor axis 0.84 to 0.86 mm. in length. *Anchovia brownii* (anchovy).

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[a] On the young stages of some osseous fishes (part III). Proceedings, American Academy of Arts and Sciences, vol. XVII, 1882, p. 271.

[b] The development of osseous fishes: I. The pelagic stages of young fishes. II. The pre-embryonic stages of development. Memoirs, Museum of Comparative Zoology, Harvard College, vol. XIV, no. 1, pt. I, p. 1, 1885; pt. II, p. 3, 1889.

[c] On the development of osseous fishes. * * * Annual Report, Commissioner of Fish and Fisheries, 1885, p. 489.

aa. Eggs with oil globules, spherical in form.

f. Egg with one (rarely two) oil globule.

g. Egg with very large perivitelline space; diameter of egg 1.4 to 1.6 mm., of yolk sphere 0.9 to 0.93 mm.; cortex of yolk sphere segmented; oil globule small, 0.12 to 0.14 mm. in diameter; pigmentation begins several hours after closure of blastopore; at time of hatching small black pigment spots are more or less closely aggregated on upper surface of head and body................*Brevoortia tyrannus* (menhaden).

gg. Egg without large perivitelline space.

h. Egg 0.7 to 0.8 mm. in diameter; a single large oil globule 0.17 to 0.2 mm. in diameter or two smaller ones which later coalesce; in well-differentiated embryo black chromatophores are sparsely scattered over its entire surface, on extra-embryonic blastoderm and oil globule, being relatively large at time of hatching. *Poronotus triacanthus* (butterfish).

hh. Eggs 0.85 to 1 mm. in diameter.

i. Oil globule transparent, small, less than 0.18 mm. in diameter.

j. Egg 0.85 to 0.9 mm. in diameter; pigmentation first observed in embryos of 15 to 20 somites; black and yellow pigment cells sparsely scattered over embryo and oil globule, and these increase in number and size; before hatching the yellow chromatophores have become aggregated to form heavily pigmented areas..............................*Stenotomus chrysops* (scup).

jj. Egg 0.9 to 1 mm. in diameter; oil globule about 0.125 mm. in diameter (Sienna flounder of Agassiz and Whitman).............................Species(?)

ii. Oil globule opaque, yellowish or brownish in color, 0.19 to 0.23 mm. in diameter; pigmentation appears shortly after closure of blastopore; black chromatophores become sparsely scattered over embryo and oil globule, those on posterior part of body later becoming aggregated in two vertical bands; yellow pigment behind eye, back of otocyst, along side of trunk anteriorly, and in the two vertical bands..............................*Merluccius bilinearis* (whiting).

ff. Oil globules several to many.

k. Egg 0.7 to 0.8 mm. in diameter; one or more large oil globules and numerous small ones.....................................*Urophycis chuss* (hake).

kk. Egg 1 to 1.35 mm. in diameter.

l. Egg 1 to 1.15 mm. in diameter, slightly yellowish in color but highly transparent; 10 to 25 unequal oil globules present; numerous yellow and black pigment cells are present over entire surface of embryo and extra-embryonic blastoderm, before hatching becoming fewer and more scattered. *Prionotus carolinus* (sea robin).

ll. Egg with two to five (rarely one) large oil globules and several smaller ones egg 1.15 to 1.35 mm. in diameter, transparent......*Sarda sarda* (bonito);

II. DEMERSAL EGGS.

m. Eggs attached by adhesive threads arising from egg membrane.

n. Adhesive threads arising in a tuft from one point on egg membrane.

o. Egg yellowish, semiopaque, 1.1 to 1.2 mm. in diameter; 5 to 12 large oil globules of unequal size and numerous smaller ones present; black chromatophores become sparsely scattered over embryo and blastoderm, followed by yellow ones on embryo; later black ones become aggregated in a few areas on top of head, in series along base of ventral-fin fold, and a few at base of dorsal-fin fold posteriorly......................*Menidia menidia notata* (silverside).

oo. Egg tinted with yellow, more transparent than preceding, 0.9 to 1 mm. in diameter; one or two large oil globules and few smaller ones; fewer adhesive threads (four to six) in tuft than preceding......................*Menidia beryllina cerea* (silverside).

nn. Adhesive threads scattered over surface of egg membrane.

- *p.* Egg about 1.5 mm. in diameter, yellowish, opaque; oil globules numerous, unequal, grouped together; roots of threads scattered over egg membrane . . *Fundulus heteroclitus* (common killifish).
- *pp.* Eggs smaller, 1.1 to 1.4 mm. in diameter.
  - *q.* Egg 1.1 to 1.3 mm. in diameter, slightly yellowish, almost transparent, held together by a tangle of coarse adhesive threads; 12 to 20 unequal oil globules grouped together. *Lucania parva* (rainwater fish).
  - *qq.* Egg 1.2 to 1.4 mm. in diameter, yellowish, highly transparent, held together by a tangle of very minute adhesive threads; a single large oil globule and groups of minute oil globules present. . . . . *Cyprinodon variegatus* (short minnow).
- *mm.* Egg membrane adhesive, no threads.
  - *r.* Egg about 1 mm. in diameter, yellowish, semitransparent, glutinous, with a relatively large perivitelline space after fertilization; oil globules small, unequal, scattered; embryo with very little pigment up to time of hatching. *Pomolobus æstivalis* (glut herring).
  - *rr.* Eggs larger, 1.5 to 1.7 mm. in diameter, clinging together in a rather rigid mass.
    - *s.* Egg 1.5 to 1.7 mm. in diameter, yellowish, semiopaque; oil globules numerous, very unequal in size, mostly clustered at upper pole of egg. *Gasterosteus aculeatus* (three-spined stickleback).
    - *ss.* Egg 1.5 to 1.6 mm. in diameter, darker and more opaque oil globules fewer in number and smaller than in the preceding. . . . *Apeltes quadracus* (four-spined stickleback).

TAUTOGA ONITIS (Linnæus). TAUTOG.

Spawning.—The principal spawning month for the tautog is June. Although the majority of the fish taken after July 1 were spent, eggs were abundant in the plankton as late as July 15. During the latter half of July they became gradually less abundant, but were taken in small numbers as late as August 20.

The tautog is prolific, but difficulty is experienced in obtaining eggs from captured fish in quantities sufficient for successful fish-cultural operations. Little difficulty, however, was experienced in obtaining and artificially fertilizing the eggs required for embryological study.

Eggs.—The eggs are highly transparent, spherical in form, and 0.9 to 1 mm. in diameter. The egg membrane is thin and horny. The yolk sphere contains no oil globule. The protoplasm which invests the yolk sphere in a very thin layer is finely granular and hardly perceptible until fertilization has taken place and the process of concentration that results in the formation of the blastodisc is initiated. As soon as fertilization has taken place a relatively small space, the perivitelline space, becomes apparent between the egg membrane and the delicate vitelline membrane which incloses the yolk sphere.

Blastodisc.—As soon as fertilization has taken place, the protoplasm becomes concentrated at one pole of the yolk sphere into a lenticular mass, the blastodisc. During this process the protoplasm slowly flows toward the pole of concentration. The "streaming" movements early described by Ryder [a] that occur in the protoplasmic layer during the process of concentration are less apparent in the eggs of this species than in the eggs of many other species of teleosts by reason of the extremely minute size of the protoplasmic granules. The process of concentration occupies less than one-half hour. The fully differentiated blastodisc (fig. 1, BD.) comprises nearly all the protoplasm contained in the egg. It is circular in outline and of nearly uniform thickness throughout the central area, thinning out abruptly near the periphery. At the periphery it thins out gradually into a very thin layer of protoplasm, which continues to invest the yolk sphere.

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[a] Ryder, J. A.: A contribution to the embryography of osseous fishes * * * . Report United States Fish Commission 1882, p. 455-605.

Segmentation.—The first act of cleavage occurs less than one hour after fertilization. Later acts of cleavage follow each other in rapid succession. Blastoderms in advanced stages of cleavage may be observed within four hours after fertilization.

As the moment of cleavage approaches, one axis of the blastodisc becomes somewhat longer than the other. The first plane of cleavage cuts the blastoderm at right angles to the longer axis (fig. 2). The second plane of cleavage cuts the first at right angles.

During the four-cell stage (fig. 3) the two axes of the blastoderm are approximately equal. The third planes of cleavage cut the blastoderm approximately parallel with the first (fig. 4). As the third act of cleavage occurs one axis of the blastoderm again becomes distinctly longer than the other (fig. 4). Typically, the eight blastomeres formed by the third act of cleavage lie in two symmetrical series of four cells each. As the fourth act of cleavage occurs, the two axes of the blastoderm again become approximately equal. The blastoderm now becomes more or less circular in outline and approaches true radial symmetry more and more closely as cleavage advances.

The first two or four blastomeres are usually approximately equal in size and quite symmetrical. As the third act of cleavage occurs, symmetry is usually disturbed. Early blastoderms of more than four cells show a marked lack of symmetry and frequently some disparity in the size of the constituent cells. However, blastoderms of 8, 16, and 32 cells are found occasionally which remain almost ideally symmetrical. Beyond the 64-cell stage symmetry or lack of symmetry in the arrangement of the cells is not easily observed. Blastoderms in advanced stages of cleavage usually appear radially symmetrical.

Formation of the periblast.—The cells at the margin of the blastoderm are not sharply limited peripherally, but remain continuous with the thin layer of protoplasm at the surface of the yolk. As segmentation advances this layer of protoplasm becomes concentrated at the periphery of the blastoderm into a somewhat flattened protoplasmic ridge that gives rise to the periblast (fig. 5, PB). Before this ridge of protoplasm has become fully differentiated, nuclei become apparent near the margin of the blastoderm and gradually become distributed throughout the entire protoplasmic ridge. The periblast nuclei as observed by Agassiz and Whitman,[a] doubtless are derived from the peripheral cells of the blastoderm. When fully differentiated the periblast consists of a flattened syncytial ridge of protoplasm with nuclei apparently like those of the cells in the blastoderm distributed throughout its entire extent.

Until nuclei are present throughout the peripheral area of the periblast it remains continuous with the peripheral cells of the blastoderm. As segmentation advances further the peripheral cells of the blastoderm become completely cut off from the peri-

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[a] Agassiz and Whitman: On the development of some pelagic fish eggs. Proceedings, American Academy of Arts and Sciences, vol. 20. 1884.

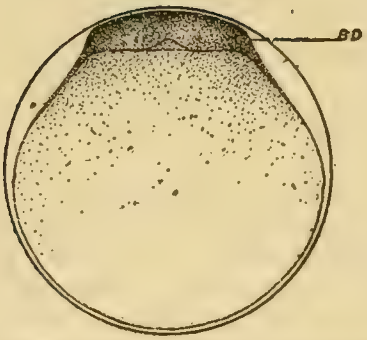

FIG. 1.—Fertilized egg with fully developed blastodisc (BD).

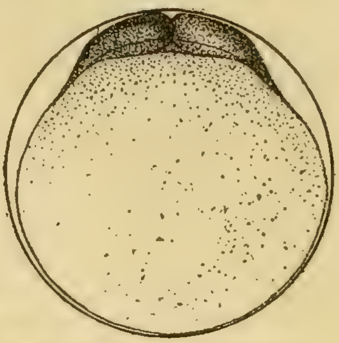

FIG. 2.—Egg with blastoderm of 2 cells.

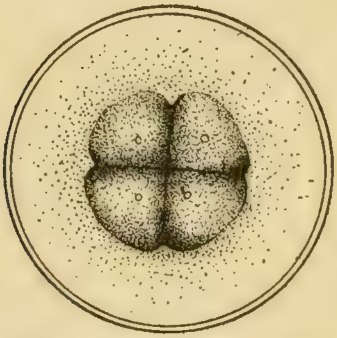

FIG. 3.—Egg with blastoderm of 4 cells.

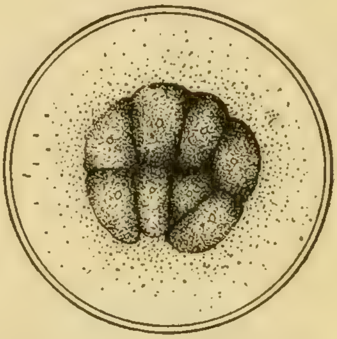

FIG. 4.—Egg with blastoderm of 8 cells.

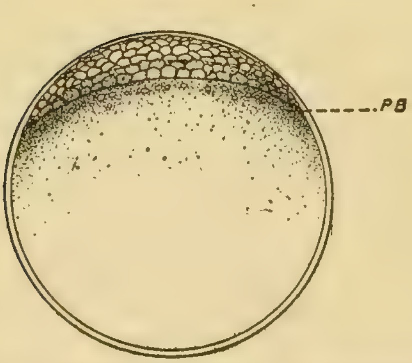

FIG. 5.—Egg with blastoderm in late cleavage stage. PB, periblast.

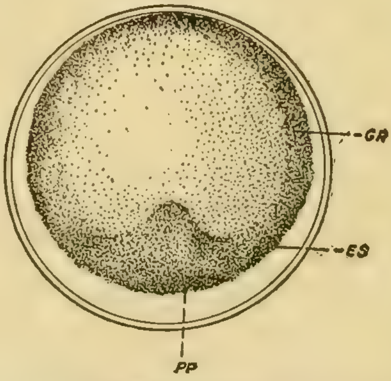

FIG. 6.—Egg with blastoderm showing germ ring (GR) fully differentiated and an early stage in the differentiation of the embryonic shield (ES). PP, posterior pole of blastoderm.

TAUTOGA ONITIS.

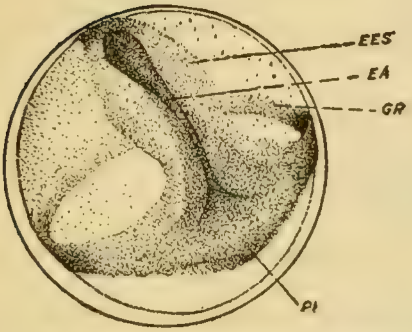

FIG. 7.—Egg showing advanced stage in differentiation of embryonic axis. EA, embryonic axis; EES, extra-embryonic area of embryonic shield; GR, germ ring; PP, posterior pole of blastoderm.

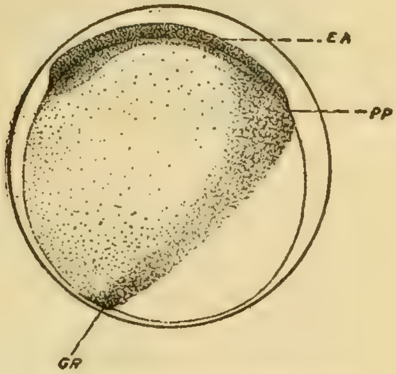

FIG. 8.—Same as figure 7, lateral view.

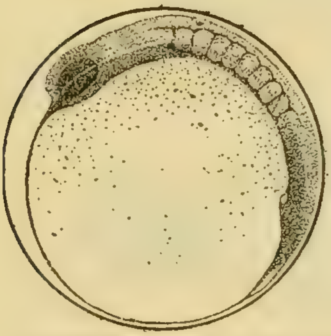

FIG. 9.—Egg with advanced embryo, with 8 somites.

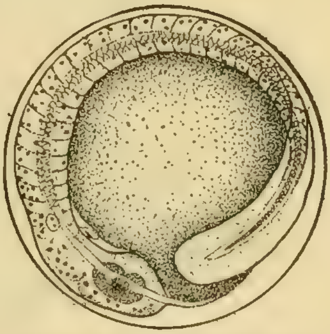

FIG. 10.—Egg with advanced embryo, shortly before hatching.

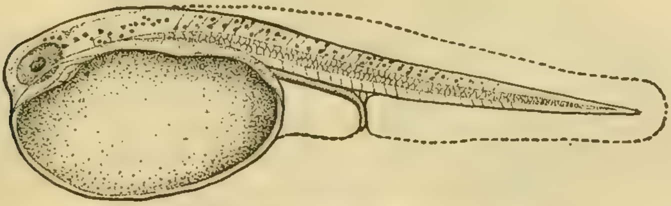

FIG. 11.—Newly hatched fish, actual length 2.1 mm.

TAUTOGA ONITIS.

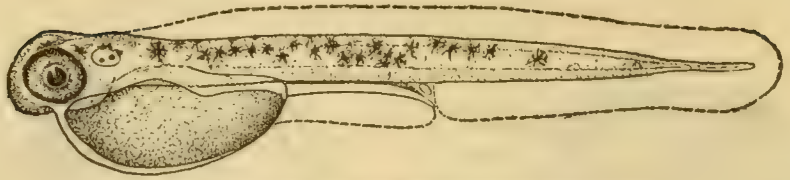

FIG. 12.—Larval fish, 1 day after hatching, actual length 2.9 mm.

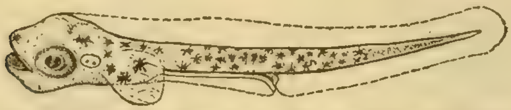

FIG. 13.—Larval fish 4 days after hatching, actual length 3.3 mm.

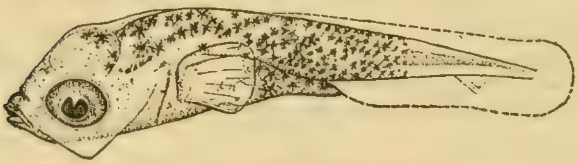

FIG. 14.—Young fish 5 mm. in length.

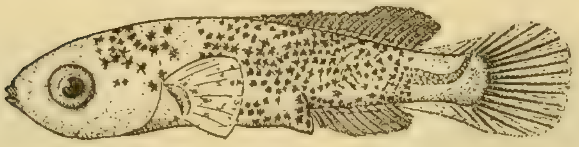

FIG. 15.—Young fish 10 mm. in length.

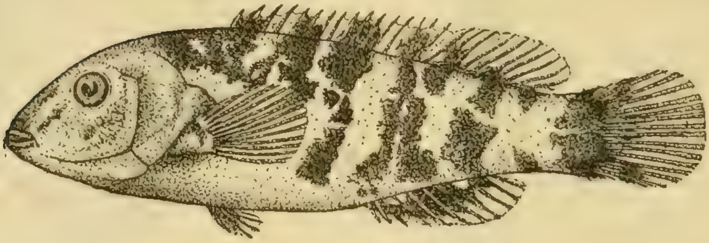

FIG. 16.—Young fish 32 mm. in length.

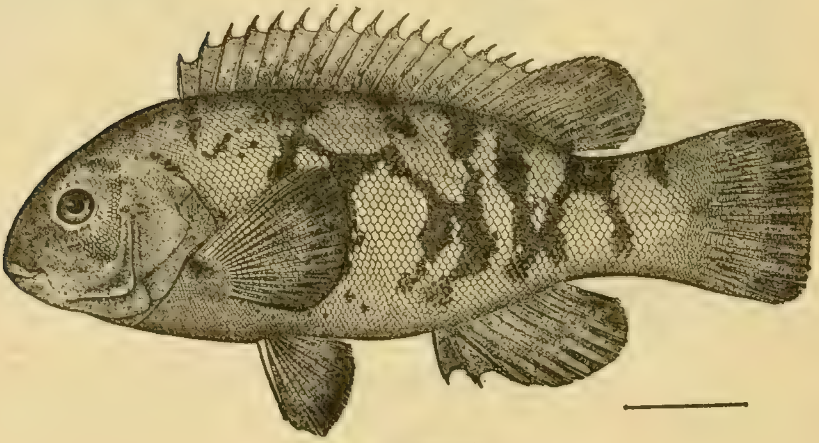

FIG. 17.—Adult fish.

TAUTOGA ONITIS.

blast. A thin sheet of protoplasm, the central periblast, which is also invaded by nuclei now advances centripetally from the periblast beneath the blastoderm.

During early cleavage the blastoderm is essentially a lenticular mass of cells. As segmentation advances, it becomes distinctly dome-shaped, leaving a cavity beneath its central area. This cavity, which is the cleavage cavity, now lies between the blastoderm and the central periblast.

Formation of the germ ring.—The germ ring, when fully differentiated, appears as a thickened peripheral zone of the blastoderm (fig. 6, GR). This zone becomes roughly outlined before the marginal cells of the blastoderm are completely cut off from the periblast. The thickening is at first more apparent than real, being due primarily to the thinning of the central area of the blastoderm, by reason of which its under surface becomes concave. After the blastoderm is completely cut off from the periblast, cells at the periphery grow inward (invaginate), thus adding somewhat to the thickness of the germ ring. Before invagination begins the cells forming the surface layer of the blastoderm become distinctly flattened. This layer plays no part in invagination. The cells which grow inward from the periphery are derived from the deeper layers. The full extent of the ingrowth of cells from the periphery of the blastoderm can not be determined in living material. For a detailed discussion of the rôle of invagination in the formation of the germ ring and the embryonic shield based on a careful study of histological sections the reader is referred to Wilson's paper on the embryology of the sea bass.[a] As the blastoderm gradually grows larger the germ ring, which in its earlier stages involves but a narrow zone, increases somewhat in width by the centrifugal growth of the blastoderm as well as by the invagination of the marginal cells.

Formation of the embryonic shield and differentiation of the embryo.—Before the germ ring is fully differentiated it becomes apparent that invagination advances more rapidly at one pole than round the rest of the periphery of the blastoderm. This is the posterior or embryonic pole (fig. 6, PP). At this pole a broad tongue of cells is pushed forward into the cleavage cavity. Viewing the blastoderm from above, there soon appears at the posterior pole a roughly triangular area which is obviously thicker than the adjacent areas. This triangular area marks an early stage in the differentiation of the embryonic shield (fig. 6, ES).

The blastoderm now increases in size more rapidly than in the earlier stages, and the germ ring gradually advances around the yolk sphere. As the blastoderm spreads over an increasingly greater area of the surface of the yolk, the embryonic shield grows larger and becomes more definitely outlined. Soon there occurs a linear thickening along its anteroposterior axis that marks the axis of the future embryo (fig. 7, EA). The embryonic shield is now differentiated into an embryonic and an extra-embryonic area. The further differentiation of the embryo begins in the anterior or head region and gradually advances posteriorly. Before the embryonic axis is well differentiated, the blastoderm covers more than half the surface of the yolk sphere, and the circumference of the germ ring is actually decreasing. As development advances much of the material contained in the germ ring becomes incorporated in the embryo. The part played in this process by concrescence in the sense of His[b] and confluence in the sense of Sumner[a] can not be discussed in this paper. This entire process is doubtless but a part of a larger process by which much of the material contained in the embryonic shield becomes incorporated in the body of the embryo.

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[a] Wilson, H. V.: The embryology of the sea bass (*Serranus atrarius*). Bulletin United States Fish Commission, vol. IX, 1889, p. 209–277.

[b] His, W.: Zur Frage der Langsverwachsung von Wirbelthierembryonen. Verh. d. anat. Ges., 1891, p. 70–83.

By the time the embryo is well formed the blastoderm covers approximately three-fourths of the surface of the yolk sphere. As development advances the blastoderm soon covers the entire yolk sphere and the blastopore is closed.

The closure of the blastopore occurs within 18 hours after fertilization. At this time the embryo extends approximately halfway round the circumference of the yolk sphere and segmentation of the body has already begun. Figure 9 illustrates an egg shortly after the blastopore is closed. The embryo remains highly transparent and shows no evidence of pigmentation. The beginning of pigmentation is observed in embryos with 15 to 20 somites. The chromatophores first appear as minute rounded black dots scattered over the dorsal aspect of the embryo. As the time of hatching approaches, the chromatophores become somewhat larger and show irregular pigmented processes. However, the embryo remains highly transparent (fig. 10). The extra-embryonic blastoderm remains free from pigment.

Larval development.—Incubation at laboratory temperature—i. e., in water at approximately 22° C.—occupied 42 to 45 hours. In the tidal hatching boxes at the same time incubation occupied approximately 48 hours.

The newly hatched larvæ (fig. 11) are approximately 2.2 mm. in length. The head is slightly deflected. The yolk sac remains relatively large. It is ovate-elliptical in form and free from pigment. The vent is located at some distance from the posterior margin of the yolk sac and a little more than half the length of the body from the anterior end. The depth of either dorsal or ventral fin fold is less than the depth of the body just posterior to the vent. The chromatophores have grown somewhat larger, but have not increased materially in numbers. They remain confined more or less closely to the dorsal and dorsolateral aspects of the body. The fin folds and the posterior caudal region of the body remain entirely free from pigment.

One day after hatching (fig. 12) the larvæ have grown to a length of 2.8 to 3 mm. The yolk sac is greatly reduced and the head is no longer deflected. The chromatophores have increased materially in size and show well-developed pigmented processes, but are apparently fewer in number than in the newly hatched larvæ. Individual pigment cells, doubtless, have become intimately associated with each other to form larger chromatophores. The larvæ now have a distinctly blackish color.

Four days after hatching (fig. 13) the larvæ have grown to a length of 3.2 to 3.5 mm. The yolk is completely absorbed. Larvæ kept in dishes of sea water as well as those hatched in the tidal hatching boxes now begin to die rapidly. The critical period for this species, therefore, comes about the fourth day after hatching. At this stage black chromatophores are more or less uniformly distributed over the dorsal and lateral aspects of the body. However, the posterior caudal region remains free from pigment.

Figure 14 illustrates a young fish 5 mm. in length taken in the plankton. In young fishes at this stage growth is indicated more especially by the increase in the depth and thickness of the body than by the increase in length. The distribution of pigment remains essentially the same as in larvæ four days after hatching. However, the chromatophores are larger and have increased materially in numbers.

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[a] Sumner, F. B.: Kupffer's vesicle and its relation to gastrulation and concrescence. New York Academy of Sciences, Memoirs, vol. II, pt. II, 1900, p. 47–83.

In young fish 10 mm. in length (fig. 15) the dorsal, anal, and caudal fins are becoming well differentiated. The distribution of pigment remains essentially as in the early stages. However, the number of chromatophores, as well as the quantity of pigment, has materially increased.

As development advances the young fish gradually assume adult characters. Young fish 30 mm. in length (fig. 16) exhibit nearly all the diagnostic characters of the species. The depth of the body in proportion to its length is rapidly increasing and the back is becoming strongly arched. The ground color of the body at this stage is greenish. The black chromatophores have become aggregated to form heavily pigmented areas, which are roughly arranged in transverse bands and give the body the transversely banded appearance characteristic of the adult.

TAUTOGOLABRUS ADSPERSUS (Walbaum). CUNNER.

Spawning.—This species spawns in June and July. The majority of the fish taken after July 1 were spent. However, eggs were abundant in the plankton until July 15 and were taken in small numbers as late as August 15.

Eggs.—The eggs are transparent, spherical in form, and 0.75 to 0.85 mm. in diameter. They contain no oil globules and can be distinguished from the eggs of *Tautoga onitis* only by a slight difference in size, the latter having a diameter of 0.9 to 1 mm.

Embryology.—The embryological development of the eggs of this species is typical of pelagic teleostean eggs. It conforms in all essential details to the course of development as outlined for the eggs of *Tautoga onitis* and will not, therefore, be discussed in detail. Early and advanced stages of cleavage are illustrated in figures 18 to 21. Figure 22 illustrates an egg in which the embryonic axis is becoming well differentiated.

Pigmentation is first observed in embryos which show 10 to 15 somites. The earliest chromatophores appear as minute black dots distributed over the dorsal aspect of the body. The extra-embryonic blastoderm remains free from pigment. The distribution of chromatophores during the early stages is essentially the same as in embryos of *Tautoga onitis*, and the blastoderm does not undergo any material change until after hatching. However, in the latter species the chromatophores are more numerous and somewhat larger.

Larval development.—Incubation at laboratory temperature occupied approximately 40 hours. The newly hatched larvæ (fig. 24) are 2 to 2.2 mm. in length. The yolk sac remains relatively large, and the head is slightly deflected. The vent is located some distance from the posterior margin of the yolk sac and a little more than half the length of the body from the anterior end. The depth of either dorsal or ventral fin fold is greater than the depth of the body posterior to the vent. The chromatophores remain small and are limited almost entirely to the dorsal and dorsolateral aspects of the body. The posterior caudal region and the fin folds remain free from pigment.

Soon after hatching the distribution of pigment undergoes a marked change. The chromatophores gradually become aggregated into compact masses, as illustrated in figure 25, in a larval fish less than one day after hatching. These masses of chromatophores become aggregated still further to form a heavily pigmented area in the dorsal region of the abdominal cavity, another just over the vent, and a third on the ventral aspect of the body approximately halfway from the vent to the tip of the tail. These pigmented areas are illustrated in figure 26 in a larval fish three days after hatching.

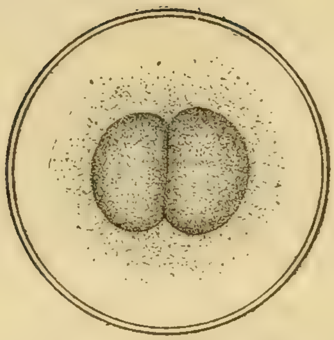

FIG. 18.—Egg with blastoderm of 2 cells.

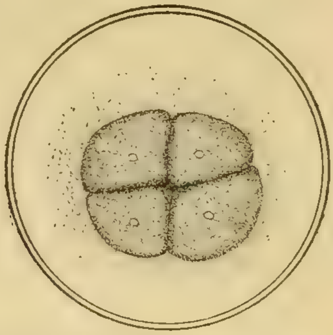

FIG. 19.—Egg with blastoderm of 4 cells.

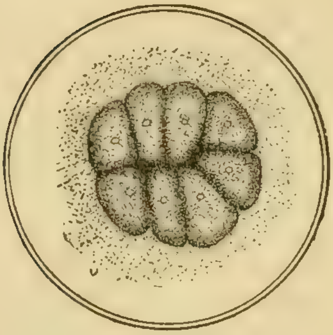

FIG. 20.—Egg with blastoderm of 8 cells.

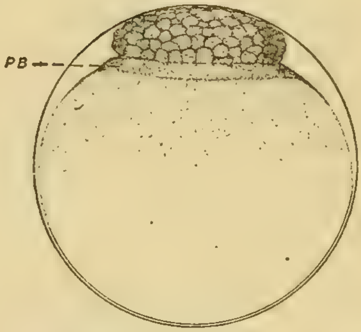

FIG. 21.—Egg with blastoderm in advanced stage of cleavage and periblast (PB) differentiated.

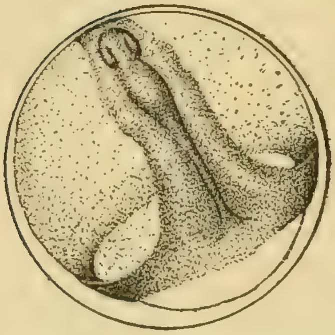

FIG. 22.—Egg showing a moderately advanced stage in the differentiation of the embryo.

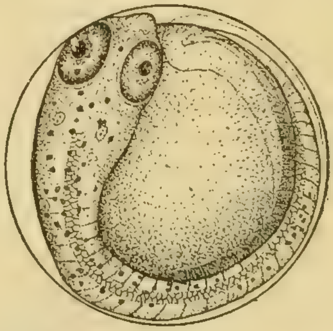

FIG. 23.—Egg showing advanced embryo.

TAUTOGOLABRUS ADSPERSUS.

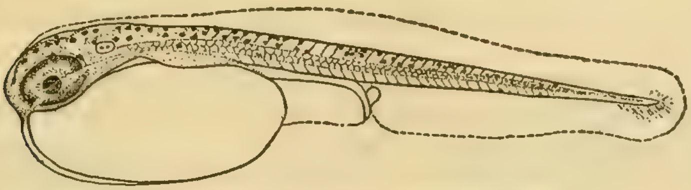

Fig. 24.—Newly hatched fish, actual length 2.2 mm.

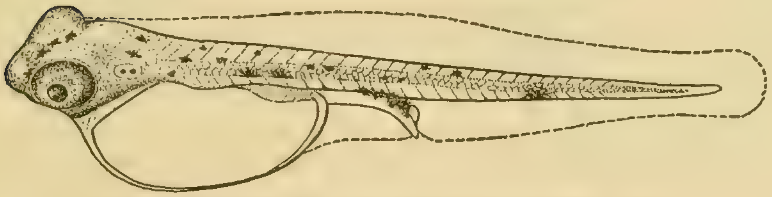

Fig. 25.—Larval fish less than 1 day after hatching, actual length 2.5 mm.

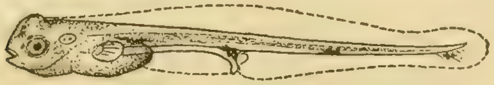

Fig. 26.—Larval fish 3 days after hatching, actual length 2.8 mm.

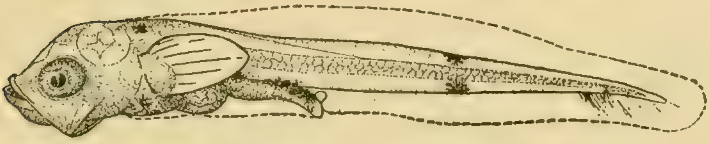

Fig. 27.—Young fish 4.2 mm. in length.

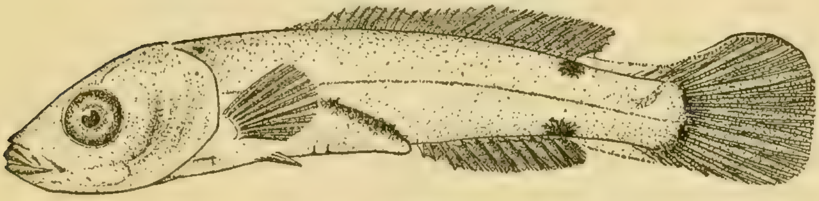

Fig. 28.—Young fish 8 mm. in length.

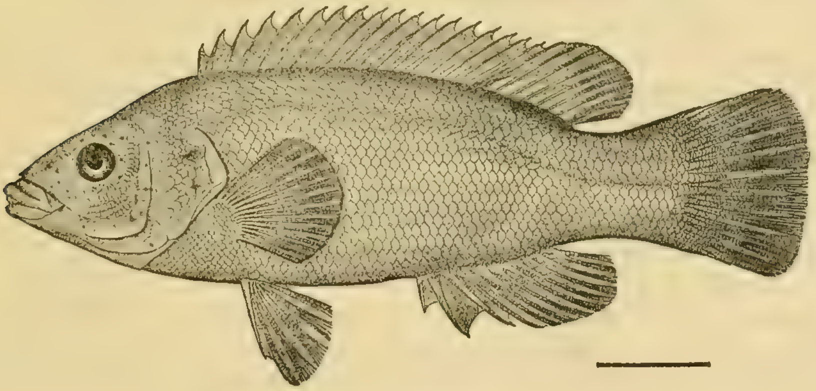

Fig. 29.—Adult fish.
TAUTOGOLABRUS ADSPERSUS.

At this time the yolk is completely absorbed and the larval fish have grown to a length of 2.8 to 3 mm.

During the fourth day after hatching, larval fish kept in dishes of sea water began to die rapidly. Few survived beyond the fifth day. The critical period comes somewhat earlier for this species than for *Tautoga onitis*.

As the young fish grow older, one or more small pigmented areas appear dorsally just posterior to the head, another on the dorsal aspect of the body opposite the one on the ventral aspect and halfway from the vent to the tip of the tail, and one or two very small areas at the base of the ventral-fin fold near the tip of the tail. These, in addition to the pigmented areas shown in figure 26, are illustrated in figure 27 in a young fish 4.2 mm. in length.

In young fish 8 mm. in length (fig. 28) the distribution of pigmented areas remains essentially as in the preceding stage. However, the two small areas which appear at the base of the ventral-fin fold near the tip of the tail now appear at the base of the caudal fin at the posterior end of the body. The dorsal, anal, and caudal fins are now well differentiated and the young fish are gradually assuming adult characters.

STENOTOMUS CHRYSOPS (Linnæus). SCUP.

Spawning.—As is well known, this species spawns largely in June. The majority of the fish taken after July 1 were spent. Eggs were not abundant in the plankton at any time during July, but were taken in small numbers as late as August 15.

Eggs.—The eggs are transparent, spherical in form, and 0.85 to 0.90 mm. in diameter. The yolk sphere contains a single oil globule which normally rests at the upper pole. The egg membrane is thin and horny.

Embryology.—The embryological development of this species, like that of the species above described, is entirely typical of teleosts with pelagic eggs. It conforms so closely to the course of development as outlined above for *Tautoga onitis* that a detailed description would be superfluous. The eggs being somewhat smaller than those of the last-named species, development advances somewhat more rapidly. In water at approximately 22° C. incubation occupied not over 40 hours.

Pigmentation is first observed in embryos showing 15 to 20 somites. Black and yellow pigment cells appear sparsely scattered over the embryo and the oil globule. As development advances, these pigment cells become larger and more numerous. In figure 31 yellow pigment on the embryo is indicated by coarse stippling, while the black is shown in solid color. As the time of hatching approaches, the yellow chromatophores become aggregated to form heavily pigmented areas. The extra-embryonic blastoderm remains free from pigment.

Larval development.—The newly hatched larvæ (fig. 32) are approximately 2 mm. in length. The head projects slightly beyond the anterior end of the yolk sac and is not appreciably deflected. The oil globule remains in the posterior end of the yolk sac. The vent is located a short distance from the posterior margin of the yolk sac, but less than half the length of the body from the anterior end. Small groups of black chromatophores remain sparsely scattered over the dorsal and dorsolateral aspects of the body. The yellow pigment is distributed as follows: A few small areas on the dorsal and lateral aspects of the head, a lateral area just posterior to the otocyst, a small area above the vent, another opposite the vent on the dorsal aspect of the body, and a

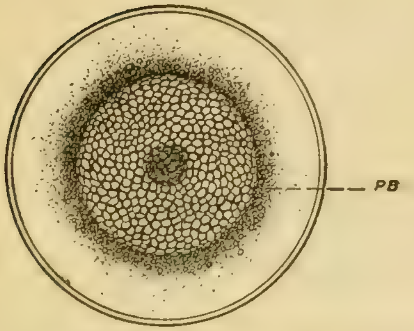

FIG. 30.—Egg with blastoderm in advanced stage of cleavage, periblast (PB) differentiated.

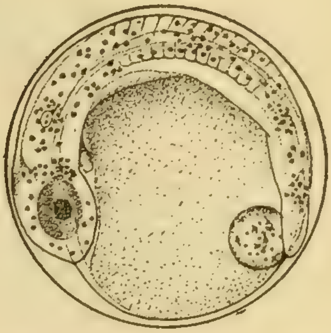

FIG. 31.—Egg showing advanced embryo.

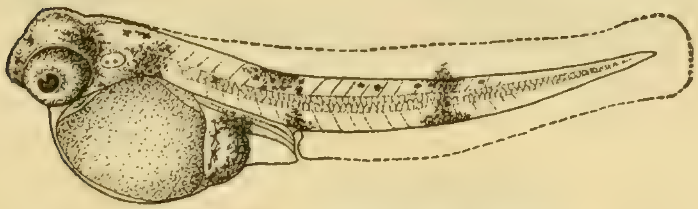

FIG. 32.—Larval fish several hours after hatching, actual length 2 mm.

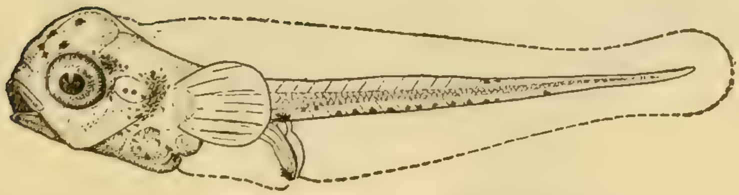

FIG. 33.—Larval fish 3 days after hatching, actual length 2.8 mm.

STENOTOMUS CHRYSOPS.

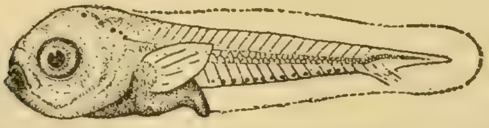

FIG. 34.—Young fish 5 mm. in length.

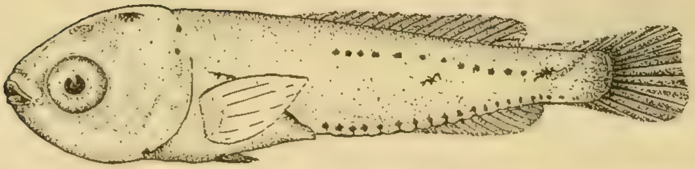

FIG. 35.—Young fish 10.5 mm. in length.

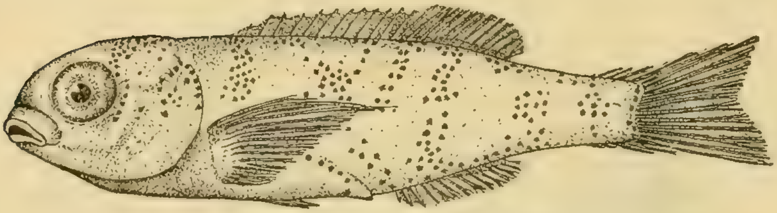

FIG. 36.—Young fish 25 mm. in length.

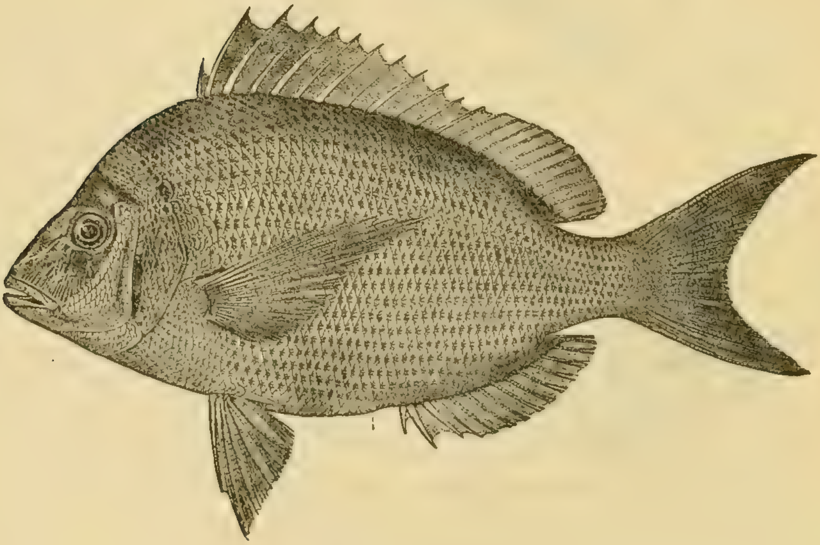

FIG. 37.—Adult fish.

STENOTOMUS CHRYSOPS.

transverse band approximately halfway from the vent to the posterior end of the body extending from the base of the ventral-fin fold onto the dorsal-fin fold. Both black and yellow chromatophores remain associated with the oil globule.

As development advances the transverse yellow band soon disappears. Before the close of the third day after hatching, when the larval fish are 2.8 to 3 mm. in length (fig. 33), the yellow pigment is greatly reduced. A small yellow area remains just back of the eye, another at the posterior margin of the opercle, and a third over the vent. A little yellow pigment also remains more or less diffusely scattered over the anterior region of the body. The distribution of black pigment also has undergone a marked change. A few small areas occur on the dorsal aspect of the head and the lateral aspect of the anterior region of the trunk. The young fish is marked further by a black spot at the anterior aspect of the vent and a series of black spots near the base of the ventral fin-fold posterior to the vent. At this stage the yolk is completely absorbed and the head is relatively large.

During the fourth and fifth days after hatching, the larval fish kept in dishes of sea water died rapidly. Few survived until the sixth day.

In young fish 5 mm. in length (fig. 34) little yellow pigment remains. The black spot at the vent also has disappeared, but the characteristic series of black spots near the base of the ventral-fin fold has become more prominent. The young fish is relatively plump anteriorly and tapers gradually toward the posterior end.

Young fish 10 mm. in length (fig. 35) show increased pigmentation in the dorsal region of the abdominal cavity. The series of black spots on the ventrolateral aspect of the body still remains. In addition a series of black spots has become apparent along the lateral line over the posterior half of the body. Dorsal, anal, and caudal fins are becoming well differentiated.

Young fish 25 mm. in length (fig. 36) already show some of the diagnostic characters of the species. The body is relatively plump, but the back is not arched as in the adult, consequently the depth of the body is relatively small. The ground color of the body is brownish yellow. Black chromatophores have increased materially in numbers and are arranged in somewhat irregular transverse bands that give the young fish the transversely banded appearance characteristic of the young of this species.

PRIONOTUS CAROLINUS (Linnæus). SEA ROBIN.

Spawning.—This species spawns in June, July, and early August. Fish ripe for stripping were taken in small numbers during the first half of July. Eggs were abundant in the plankton throughout July and were taken in small numbers as late as August 24. The spawn is abundant, and no difficulty was experienced in obtaining and artificially fertilizing eggs for embryological study.

Eggs.—The eggs (fig. 38) are spherical in form and 1 to 1.15 mm. in diameter. They are slightly yellowish in color, but highly transparent. The yolk sphere contains a variable number (10 to 25) of oil globules of unequal size scattered over the surface. As development advances, some of these oil globules may become aggregated. Usually, however, they remain distributed more or less uniformly over the surface of the yolk. The egg membrane is thin and horny.

Embryology.—These eggs develop in a manner typical of pelagic teleostean eggs. They are somewhat larger than the eggs of *Tautoga onitis*, and therefore development

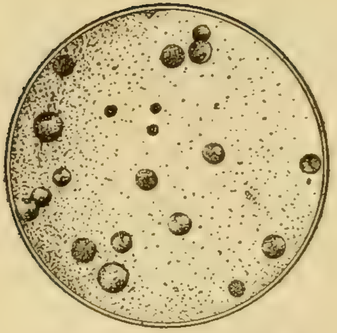

FIG. 38.—Mature unfertilized egg.

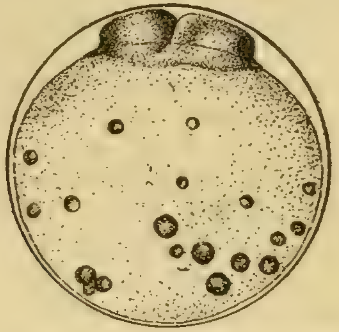

FIG. 39.—Egg with blastoderm of 2 cells.

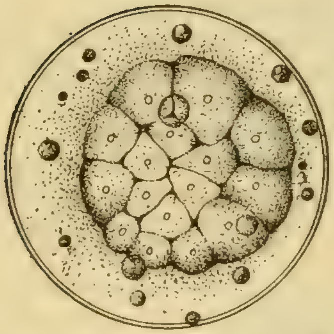

FIG. 40.—Egg with blastoderm of 16 cells.

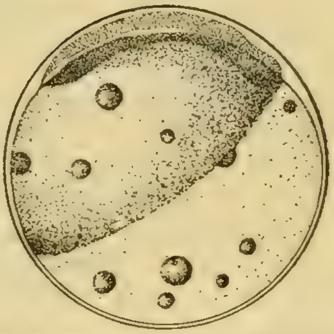

FIG. 41.—Egg showing early stage in the differentiation of the embryo.

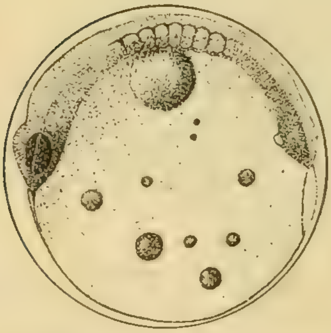

FIG. 42.—Egg with embryo well differentiated, blastopore, closed.

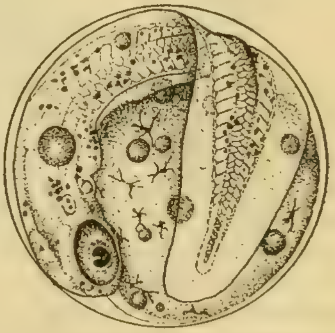

FIG. 43.—Egg with advanced embryo.

PRIONOTUS CAROLINUS.

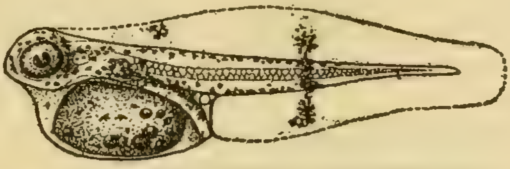

FIG. 44.—Newly hatched fish, actual length 2.8 mm.

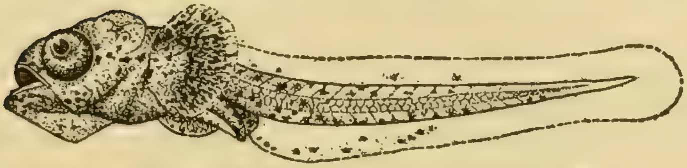

FIG. 45.—Larval fish 5 days after hatching, actual length 3.1 mm.

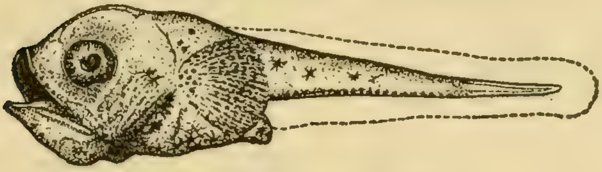

FIG. 46.—Young fish 4 mm. in length.

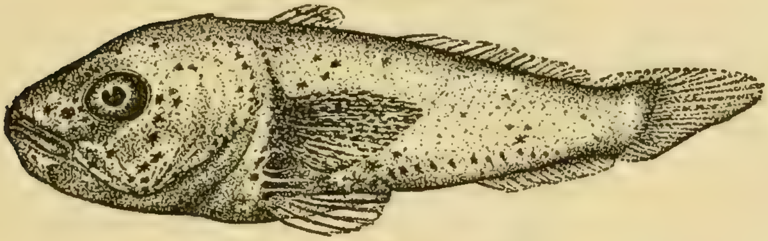

FIG. 47.—Young fish 9 mm. in length.

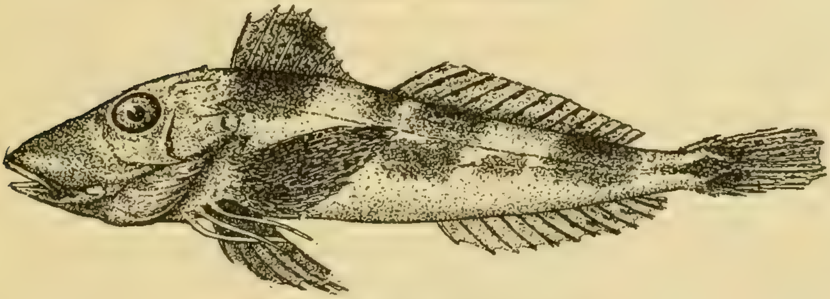

FIG. 48.—Young fish 30 mm. in length.

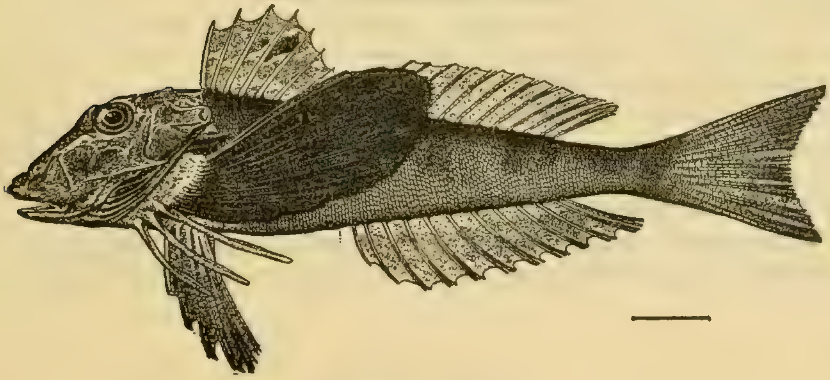

FIG. 49.—Adult fish.

PRIONOTUS CAROLINUS.

advances somewhat less rapidly. The volume of protoplasm in proportion to the volume of yolk is relatively small, yet the blastodisc is relatively thick; consequently, during the early stages of cleavage (fig. 39) the blastoderm covers a relatively small area of the surface of the yolk sphere.

The first act of cleavage occurs within 1.5 hours after fertilization. The successive acts of cleavage follow each other very regularly. The early blastoderms are usually more nearly symmetrical than are those of *Tautoga onitis* or either of the other species described. A blastoderm of 16 cells in which symmetry is somewhat disturbed is illustrated in figure 40.

Within 20 hours after fertilization (fig. 42) the embryo is well differentiated and extends halfway around the circumference of the yolk sphere. The blastopore is not yet closed. The embryo shows 10 to 12 somites and pigmentation has already begun. Numerous yellow and black pigment cells are present over the entire surface of the embryo and in the adjacent areas of the extra-embryonic blastoderm. Pigment cells arise earliest in the embryo and gradually become apparent in the remoter parts of the blastoderm. Yellow pigment arises somewhat earlier than black pigment in these embryos.

At 42 hours after fertilization (fig. 43) both black and yellow chromatophores are larger and fewer in number than during the earlier stages. They are now sparsely distributed over the surface of the embryo and throughout the extra-embryonic blastoderm.

Larval development.—Incubation in water at a temperature about 22° C. occupied approximately 60 hours. The newly hatched larvæ (fig. 44) are approximately 2.8 mm. in length. The yolk sac is relatively small and still contains oil globules. The head is not markedly deflected. The vent is located just posterior to the yolk sac. The pectoral fins are prominent. The depth of either dorsal or ventral fin fold is greater than the depth of the body posterior to the vent. Black and yellow chromatophores are sparsely scattered over the head, the anterior region of the trunk, and the dorsolateral and ventrolateral aspects of the trunk farther posteriorly. The body is marked further by two transverse yellow bands, one just posterior to the pectoral fins, the other approximately halfway from the vent to the posterior end of the body. These bands of pigment extend onto the fin folds. The general color of the head and pectoral fins is yellowish. In figures 44 and 45 black pigment is indicated by solid color, while yellow pigment is indicated by short lines.

As development advances a material reduction of the yellow pigment becomes apparent. Five days after hatching (fig. 45) the yellow markings characteristic of the newly hatched larvæ are no longer apparent. The head and the pectoral fins still show yellow pigment. Some yellow chromatophores also remain at the vent and at the former location of the posterior transverse band. Black chromatophores are sparsely scattered over the body and a few appear also in the dorsal and ventral fin folds. The posterior caudal region remains practically free from pigment.

Larval fish five days old have grown to a length of 3.1 to 3.4 mm. The head is relatively large. The pectoral fins are large and prominent. The critical period for this species is reached during the fifth or sixth day after hatching; when kept in dishes of sea water, few survived until the seventh day.

Young fish 4 mm. in length (fig. 46) are characterized by a very large head and relatively great depth of the body in the anterior region of the trunk. The ground color of the body remains yellowish. Black chromatophores occur sparsely scattered over the dorsal and lateral aspects of the body and in a series along the ventrolateral aspect of the body near the base of the ventral-fin fold.

In young fish 8 to 10 mm. in length (fig. 47) the dorsal, anal, and caudal fins are becoming well differentiated, and the free rays of the pectoral fins characteristic of the species are already present. The general color of the body and the distribution of black chromatophores remain essentially as in the preceding stage.

In young fish 25 to 30 mm. in length (fig. 48) the general color of the body has become darker, and the trunk is marked by heavily pigmented areas that give it a transversely banded appearance. The fins are well differentiated. The head is long and somewhat pointed and shows the bony structure characteristic of the adult. The young fish are gradually assuming the appearance of the adults and already show many of the diagnostic characters of the species.

MERLUCCIUS BILINEARIS (Mitchill). WHITING.

Spawning.—Eggs of this species were present in small numbers in the plankton late in July and throughout August. Males ripe for stripping and females nearly ripe were taken in the traps in Menemsha Bight late in July. A few females apparently ripe for stripping were taken in the same traps on August 6. The eggs were successfully fertilized, but all died during early cleavage. The majority of the fish taken in these traps on August 16 were smaller than those taken earlier. Among them were found a number of spent females. but none ripe for stripping. Apparently the spawning period for this species is a protracted one and not all the eggs mature at one time.

Eggs.—The eggs are highly transparent, spherical in form, and 0.88 to 0.95 mm. in diameter. The yolk sphere contains a relatively opaque, yellowish or brownish oil globule 0.19 to 0.23 mm. in diameter. The protoplasmic layer is finely granular. The egg membrane is thin and horny.

Embryology.—The embryological development of this species is entirely typical and does not differ essentially from the course of development as outlined for *Tautoga onitis*. Early and advanced stages of cleavage are illustrated in figures 50 and 51.

Pigmentation begins soon after the closure of the blastopore. At this time the embryo extends approximately halfway around the circumference of the yolk sphere. Black chromatophores become sparsely scattered over the embryo and the oil globule. The extra-embryonic blastoderm remains free from pigment. The distribution of chromatophores several hours after the beginning of pigmentation is illustrated in figure 52.

As the time of hatching approaches (fig. 53), yellow pigment also becomes apparent on the embryo. Yellow pigment areas occur just back of the eye, back of the otocyst, in a series along the lateral surface of the anterior region of the trunk, and in two vertical bands on the posterior half of the body. The distribution of black pigment on the anterior half of the body remains essentially as in the earlier stages. Farther posteriorly all the black chromatophores have become aggregated in two vertical bands.

Larval development.—Incubation occupied not over 48 hours. The newly hatched larvæ (fig. 54) are approximately 2.8 mm. in length and relatively slender. The head is slightly deflected at the anterior end of the yolk sac. The vent is located immediately

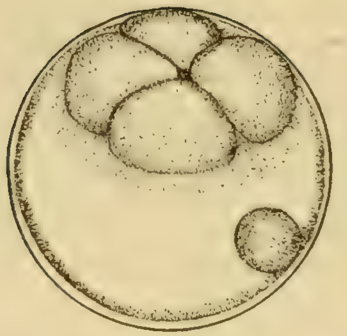

FIG. 50.—Egg with blastoderm of 4 cells.

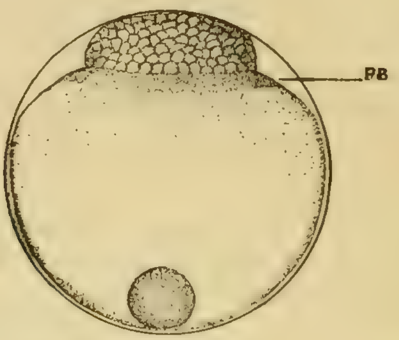

FIG. 51.—Egg with blastoderm in advanced stage of cleavage, periblast (PB) differentiated.

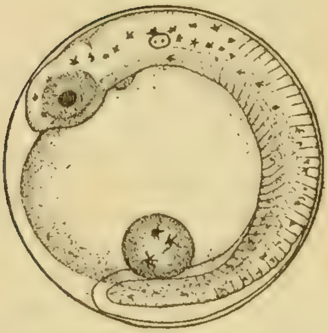

FIG. 52.—Egg with moderately advanced embryo.

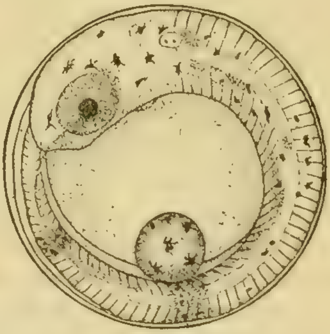

FIG. 53.—Egg with advanced embryo.

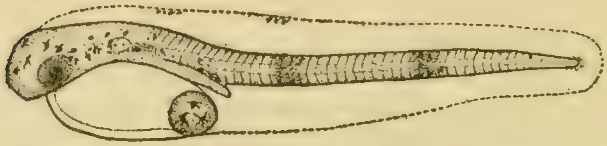

FIG. 54.—Newly hatched fish, actual length 2.8 mm.

MERLUCCIUS BILINEARIS.

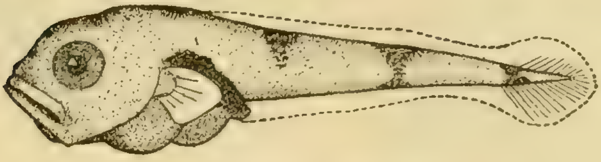

FIG. 55.—Young fish 6.5 mm. in length.

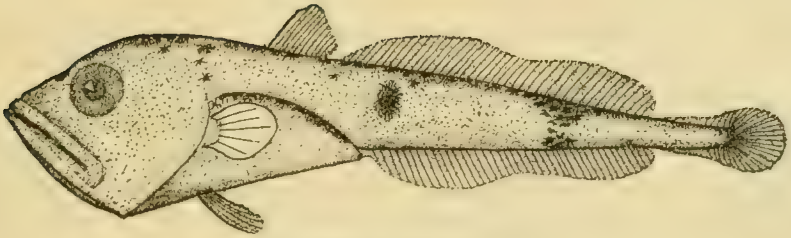

FIG. 56.—Young fish 11 mm. in length.

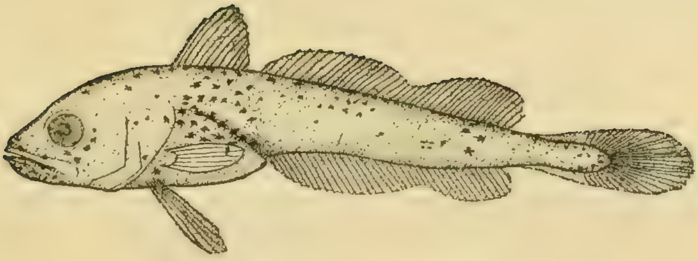

FIG. 57.—Young fish 23 mm. in length.

MERLUCCIUS BILINEARIS.

posterior to the yolk sac, not at the margin, but laterally near the base of the ventral-fin fold. The depth of either dorsal or ventral fin fold is greater than the depth of the body posterior to the vent. Black chromatophores occur sparsely scattered over the head and anterior trunk region and on the oil globule. Two small groups occur also near the margin of the dorsal-fin fold. A small yellow area occurs laterally just posterior to the otocyst. Farther posteriorly the body is marked by two vertical bands of black and yellow pigment, one of which is located a short distance posterior to the vent and the other somewhat more than half the distance from the vent to the posterior end of the body.

All the newly hatched larvæ kept in the laboratory died within 24 hours. Neither were larvæ of this species taken in the plankton. The later stages here described were selected from specimens taken by W. W. Welsh at or near the surface at the Grampus station 10258, August 25, 1914, about 20 miles south of Marthas Vineyard, Mass.

A young fish 6.5 mm. in length is illustrated in figure 55. At this stage the head is relatively large, and the body tapers gradually toward the posterior end. The lateral position of the vent is still apparent. The dorsal region of the abdominal cavity is heavily pigmented. Large black chromatophores occur on the dorsal aspect of the head and the anterior region of the trunk. The body is marked further by a vertical band just posterior to the vent, another approximately halfway from the vent to the posterior end of the body, and a third near the posterior end of the body.

In young fish 11 mm. in length (fig. 56) the head remains relatively large. The dorsal, anal, and caudal fins are becoming well differentiated. The dorsal region of the abdominal cavity remains heavily pigmented. Large black chromatophores now occur along the entire dorsal aspect of the body except in the caudal region. The three vertical bands described above are still present but are less distinct than in the earlier stages.

In young fish 20 to 25 mm. in length (fig. 57) the pigmentation characteristic of the earlier stages is no longer apparent. The dorsal and dorsolateral aspects of the body are more or less uniformly, but only lightly, pigmented. The head is long and the body is relatively slender. The young fish are now gradually assuming the general appearance of adults and already show some of the diagnostic characters of the species.

PORONOTUS TRIACANTHUS (Peck). BUTTERFISH.

Spawning.—The spawning habits of this species are practically unknown. The data available indicate that these fish leave the inshore waters during the spawning season. In the Woods Hole region, there is a run of fish in June, lasting a week or longer. After this relatively few butterfish are taken in the inshore waters until about September 1, when they again become abundant. During the first half of July, 1915, adult butterfish were taken in considerable numbers and daily examinations made. The majority of the males were ripe for stripping, and many of the females were apparently nearly ripe. However, mature eggs could not be obtained. After July 15 the catch gradually fell off until relatively few butterfish were taken. The majority of these were smaller than those taken early in July. About August 15 fish of larger size again were taken, but these were spent. At this time schools of butterfish were reported offshore.

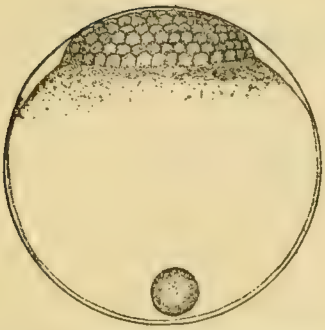

FIG. 58.—Egg with blastoderm in advanced stage of cleavage.

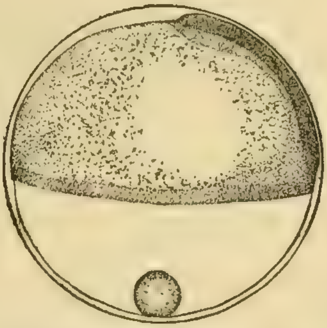

FIG. 59.—Egg showing advanced stage in differentiation of embryonic axis.

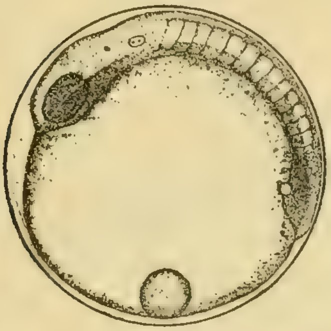

FIG. 60.—Egg with embryo showing 12 to 14 somites, blastopore closed.

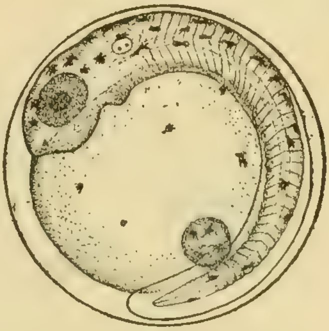

FIG. 61.—Egg with advanced embryo.

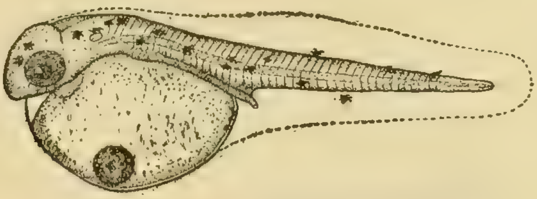

FIG. 62.—Newly hatched fish, actual length 2 mm.

PORONOTUS TRIACANTHUS.

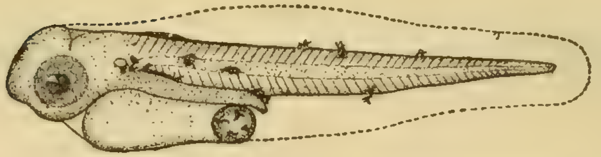

FIG. 63.—Larval fish 1 day after hatching, actual length 2.1 mm.

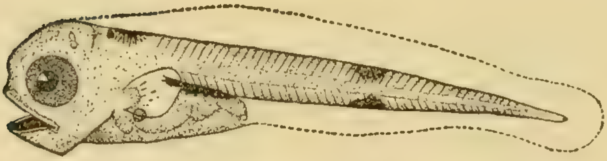

FIG. 64.—Larval fish 3 days after hatching, actual length 2.3 mm.

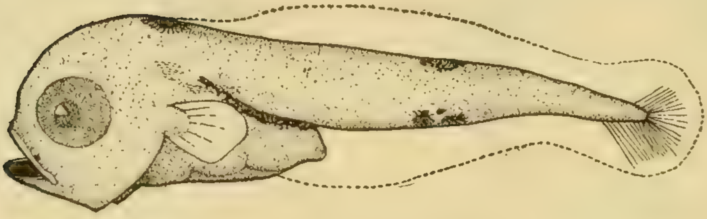

FIG. 65.—Young fish 3.2 mm. in length.

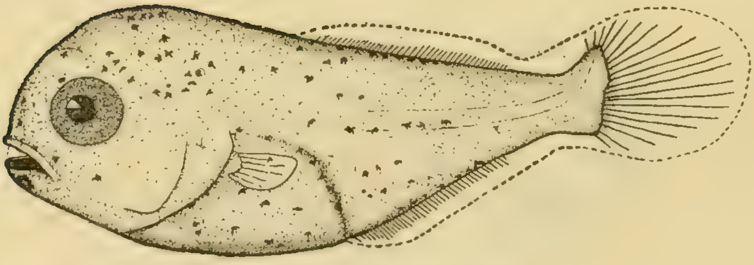

FIG. 66.—Young fish 6 mm. in length.

PORONOTUS TRIACANTHUS.

Eggs were first taken in the tow in Muskeget Channel on July 30. They were present in the plankton off Gay Head throughout August, being especially abundant on August 20. Larval fish 2 to 3.2 mm. in length were taken at this point on August 12 and again on August 16. On August 7 a young butterfish 6 mm. in length and on August 14 another 7.5 mm. in length were taken in Woods Hole Harbor. Eggs or newly hatched larvæ were never taken in the harbor. These larger young fish show many of the diagnostic characters of the species and can be positively identified. Although young fish between 3.2 and 6 mm. in length were not taken, it is believed that the eggs and smaller larval fishes here described are this species.

The authors have since learned that at the Gloucester, Mass., fisheries station, from July 15 to 31, inclusive, 609,000 eggs were secured and somewhat over 60 percent hatched. This is believed to be the first successful attempt at taking the eggs from the parent fish.

Eggs.—The eggs are transparent, spherical in form, and 0.7 to 0.8 mm. in diameter. The yolk sphere usually contains a single transparent oil globule 0.17 to 0.20 mm. in diameter. Eggs with two oil globules of smaller size are not uncommon, but as development advances these coalesce. The egg membrane is thin and horny.

Embryology.—These eggs develop in a manner typical for pelagic teleostean eggs. An advanced cleavage stage is illustrated in figure 58. Figure 59 illustrates an advanced stage in the differentiation of the embryonic axis. Figure 60 illustrates an egg shortly after the closure of the blastopore. At this time the embryo extends approximately halfway around the circumference of the yolk sphere.

As soon as the embryo is well differentiated, black chromatophores appear sparsely scattered over its entire surface as well as in the extra-embryonic blastoderm and on the oil globule. As the time of hatching approaches (fig. 61) these chromatophores become relatively large.

Larval development.—Incubation occupies less than 48 hours. The newly hatched larvæ (fig. 62) are approximately 2 mm. in length. The head is slightly deflected at the anterior end of the yolk sac. The vent is located just posterior to the yolk sac, not at the margin, but laterally, considerably above the margin of the fin fold. Large black chromatophores are sparsely scattered over the body and the oil globule. A small group of chromatophores also remains in the posterior region of the yolk sac.

Soon after hatching, a small amount of yellow pigment becomes apparent. Small yellow areas appear on the head and the dorsal surface of the body, another at the vent, and a few on the oil globule. The black chromatophores, as illustrated in figure 63, in a larval fish one day after hatching, gradually become aggregated into small groups. By the close of the third day after hatching (fig. 64) these groups of chromatophores have become aggregated still further to form a heavily pigmented area on the nape, another in the dorsal region of the abdominal cavity, a third on the ventral surface of the body less than half the distance from the vent to the tip of the tail, and a fourth directly opposite the third on the dorsal surface of the body. At this time the yolk is completely absorbed and the larvæ are approximately 2.3 mm. in length. The larval fishes kept in sea water died before the close of the fourth day.

In young fish 3.2 mm. in length (fig. 65) the head is relatively large and the anterior region of the trunk relatively deep. The distribution of pigment remains essentially as in the preceding stage.

In young fish 6 mm. in length (fig. 66) the depth of the body in proportion to its length has increased materially. Black chromatophores are sparsely scattered over the anterior two-thirds of the body, being most abundant in the area corresponding to and adjacent to the heavily pigmented areas in the preceding stage.

Figure 67 illustrates a young fish 15 mm. in length. The dorsal, anal, and caudal fins are now well differentiated, and the young fish is gradually assuming the general appearance of the adult.

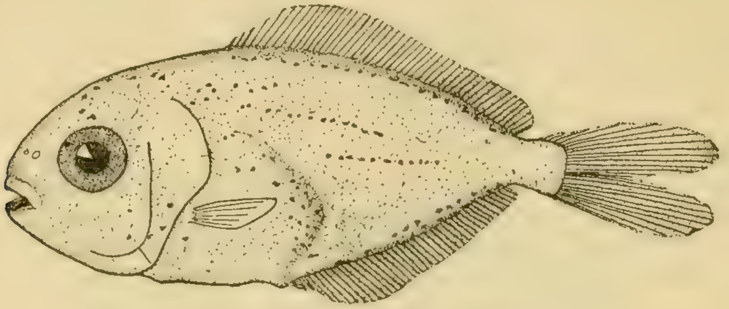

FIG. 67.—Young fish 15 mm. in length.

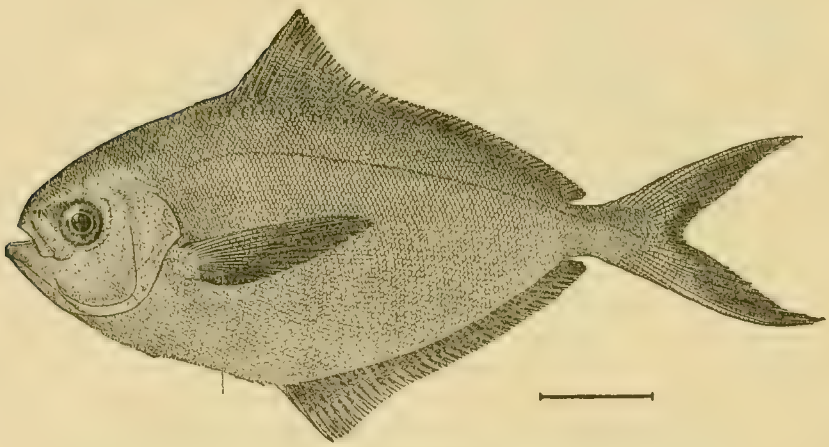

FIG. 68.—Adult fish.

PORONOTUS TRIACANTHUS.

ANCHOVIA ARGYROPHANA (Cuvier and Valenciennes). ANCHOVY.

Spawning.—The eggs of this species were present in small numbers in the plankton off Gay Head throughout August. They were at no time abundant, and none were taken in Woods Hole Harbor. The species probably spawns in offshore waters. Spawning probably occurs regularly in the evening. Eggs taken at the same hour on successive days were in approximately the same phase of development. Newly spawned eggs were not observed.

During the latter half of August adult fish were taken occasionally. Some of these were spent and none were found ripe for stripping.

Eggs.—The eggs are highly transparent and ellipsoidal in form, having a major axis of 1.15 to 1.25 mm. and a minor axis of 0.55 to 0.80 mm. The yolk is broken up by refraction planes, giving it the appearance of being made up of large cells. The eggs of this species resemble those of *Anchovia brownii* more closely than those of *Anchovia mitchilli.*[a]

Embryology.—The embryological development of these eggs differs from that of the pelagic eggs here described only in a few unimportant details. The protoplasm becomes concentrated to form the blastodisc at one pole of the major axis. As the blastoderm grows round the yolk, its posterior pole does not remain at a relatively fixed point, as is the case in many spherical teleostean eggs, but recedes as the anterior pole advances. The center of the blastoderm, therefore, remains at one pole of the major axis. (Figs. 69 and 70.) The blastopore finally closes at the opposite pole. When the embryo is fully differentiated, it lies approximately parallel with the major axis of the egg, the head being strongly deflected at the end of the yolk mass. (Fig. 71 and 72.)

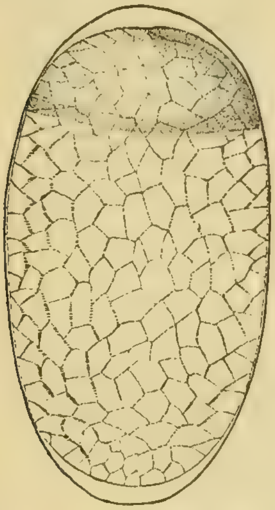

FIG. 69.—Egg showing an early stage in differentiation of embryonic axis.

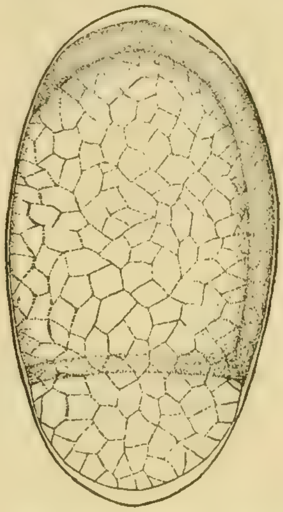

FIG. 70.—Egg showing a late stage in differentiation of embryonic axis.

ANCHOVIA ARGYROPHANA.

Larval development.—The newly hatched larvæ are approximately 3 mm. in length. The yolk sac remains relatively large and tapers to a point at the posterior end. The body is relatively slender, and the vent is located less than one-fourth the length of the body from the posterior end. Black chromatophores occur in a series along the intestine posterior to the yolk sac and at the base of the ventral-fin fold posterior to the vent. Figure 73 illustrates a larval fish approximately eight hours after hatching.

One day after hatching (fig. 74) the larvæ have grown to a length of approximately 3.4 mm. The yolk is largely absorbed. The distribution of pigment remains essentially as in the newly hatched larvæ, but the chromatophores have increased materially in size.

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[a] Kuntz, A.: The embryology and larval development of *Bairdiella chrysura* and *Anchovia mitchilli.* Bulletin Bureau of Fisheries, vol. XXXIII, 1913, p. 14.

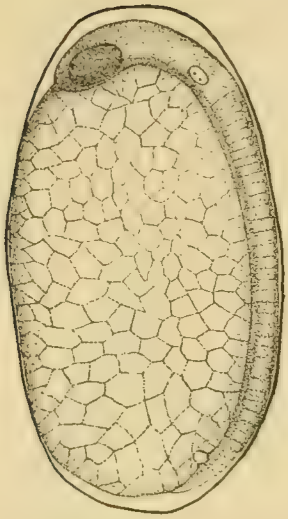

FIG. 71.—Egg with embryo well formed, shortly after closure of blastopore.

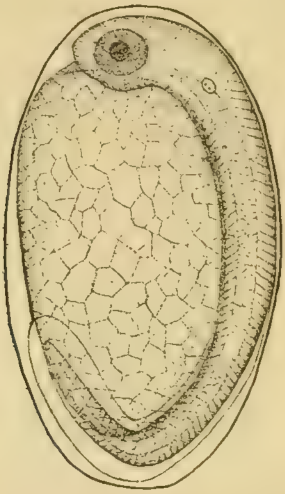

FIG. 72.—Egg with advanced embryo.

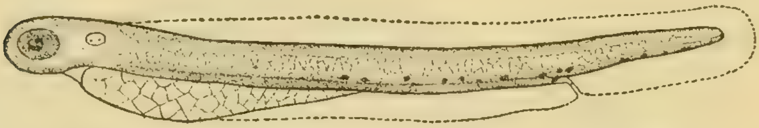

FIG. 73.—Larval fish several hours after hatching, actual length 3.2 mm.

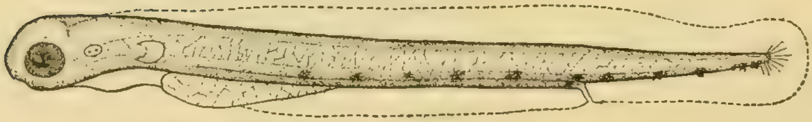

FIG. 74.—Larval fish 1 day after hatching, actual length 3.4 mm.

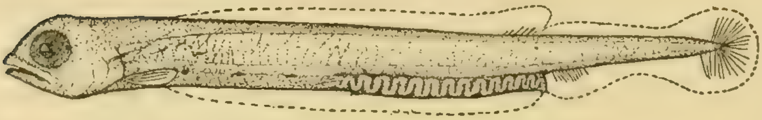

FIG. 75.—Young fish 5.2 mm. in length.

ANCHOVIA ARGYROPHANA.

In young fish 5.2 mm. in length (fig. 75) the dorsal and anal fins are becoming differentiated. In the posterior abdominal region the intestine is convoluted, as is characteristic of the young of many clupeoid fishes. The body remains almost colorless. The chromatophores along the intestine and at the base of the ventral-fin fold are less conspicuous than in the earlier stages.

BREVOORTIA TYRANNUS (Latrobe). MENHADEN, POGY.

Spawning.—For years data on the spawning habits of the menhaden have been sought with little success. Observations on the movements of the schools and examinations of the reproductive organs lead to the belief that in New England spawning takes place in late spring or early summer and that from Chesapeake Bay southward the season is late fall or early winter. Some reasons have been advanced for believing that in the Chesapeake region, at least, there are two spawning seasons. A very important addition to our knowledge of the life history of this species has recently been made by W. W. Welsh, of the Bureau of Fisheries, in identifying the larvæ. His specimens were about 24 mm. long, taken in St. George Sound, Carabelle, Fla., January 15, 1913. On February 22, 1914, examples about 30 mm. in length were taken near the mouth of the Potomac River, off Piney Point, Md., by the junior author, and on October 21, 1914, specimens about 20 mm. in length were collected in Woods Hole Harbor.

Observations made at Woods Hole this season indicate that the main body of fish spawn in June and that spawning continues throughout July and August and apparently later, as the *Grampus* obtained eggs and larvæ to the westward of Marthas Vineyard and in Nantucket Sound the last week in October, 1915. About June 30 larvæ were common in the plankton in the harbor and were not rare as late as July 20. The young, with most or all of the adult characters, were not infrequently taken in abundance between July 10 and August 10. For several days about July 21 adult fish were present in Vineyard Sound. Examinations of the reproductive organs of some of these fish indicated that they were about ready to spawn, and others were spent. Some of the males had enlarged testes with active spermatozoa, and the ovaries of some of the females were greatly distended.

Individual eggs were occasionally taken in the tow in the harbor throughout July. On August 20 they were quite abundant in the plankton off Gay Head and were still present on the 24th.

Eggs.—The eggs are highly transparent, spherical in form, and 1.4 to 1.6 mm. in diameter. The perivitelline space is very large. In this respect these eggs resemble the eggs of the shad and the European pilchard. The yolk sphere is approximately 0.9 mm. in diameter and contains a transparent oil globule 0.12 to 0.14 mm. in diameter. The egg membrane is thin and horny.

Embryology.—The embryological development of these eggs does not differ essentially from the course of development as outlined above for the eggs of *Tautoga onitis*. An advanced stage of cleavage is illustrated in figure 76. Figure 77 illustrates an advanced stage in the differentiation of the embryonic axis. Figure 78 illustrates an egg shortly after the closure of the blastopore. The embryo is relatively long and slender and at this time extends more than two-thirds around the circumference of the yolk sphere.

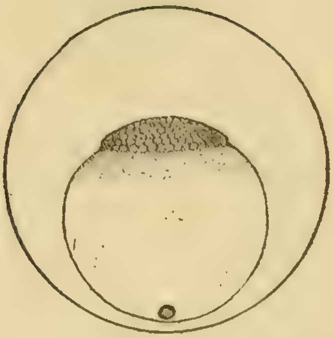

FIG. 76.—Egg with blastoderm in advanced stage of cleavage.

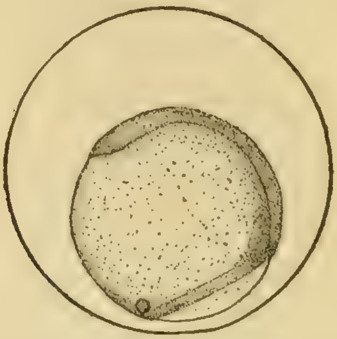

FIG. 77.—Egg showing advanced stage in differentiation of embryonic axis.

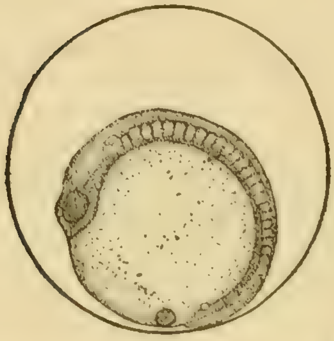

FIG. 78.—Egg showing embryo with 22 to 24 somites, blastopore closed.

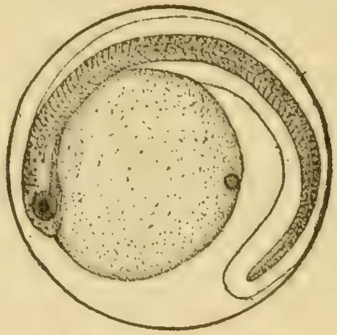

FIG. 79.—Egg with advanced embryo.

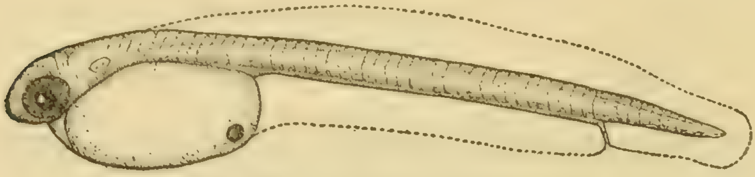

FIG. 80.—Newly hatched fish, actual length 4.5 mm.

BREVOORTIA TYRANNUS.

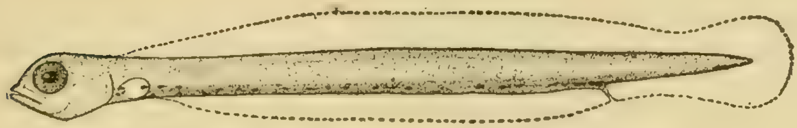

FIG. 81.—Larval fish 4 days after hatching, actual length 5.7 mm.

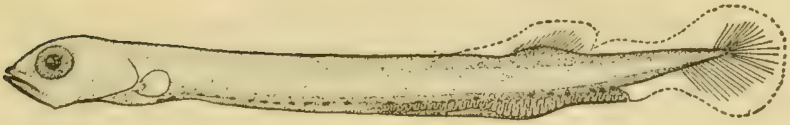

FIG. 82.—Young fish 9 mm. in length.

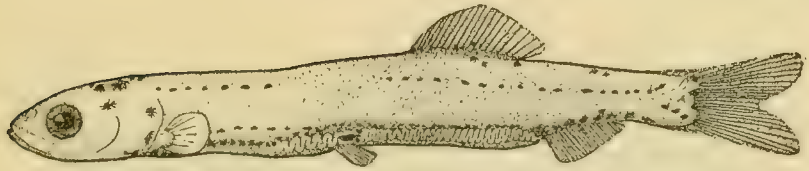

FIG. 83.—Young fish 23 mm. in length.

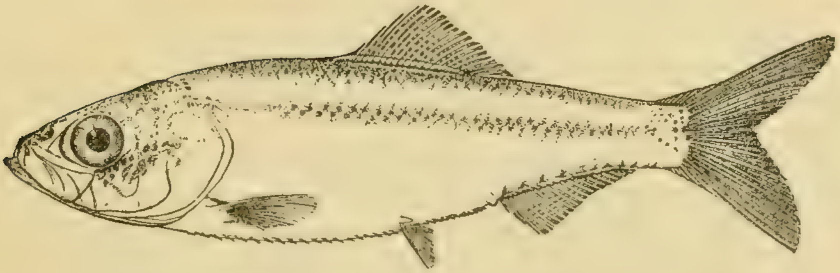

FIG. 84.—Young fish 33 mm. in length.

BREVOORTIA TYRANNUS.

Pigmentation begins within several hours after the closure of the blastopore. Before the time of hatching (fig. 79) small black chromatophores appear more or less closely aggregated on the dorsal and dorsolateral aspects of the embryo. The extra-embryonic blastoderm remains free from pigment.

Larval development.—Incubation occupies not over 48 hours. The newly hatched larvæ (fig. 80) are approximately 4.5 mm. in length and relatively slender. The head is slightly deflected at the anterior end of the yolk sac. The vent is located less than one-fifth the length of the body from the posterior end. Pigment is less abundant than before hatching. Small black chromatophores now occur on the dorsal aspect of the body near the base of the dorsal-fin fold and on the ventral aspect of the body posterior to the vent.

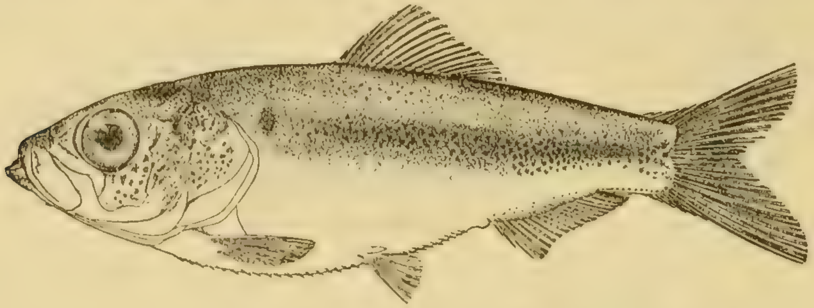

FIG. 85.—Young fish 41 mm. in length.

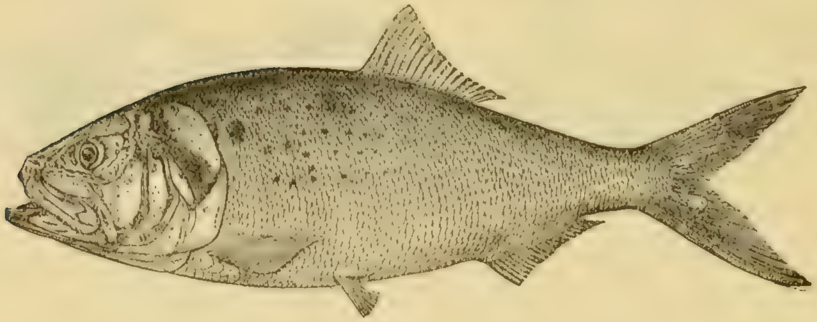

FIG. 86.—Adult fish.

BREVOORTIA TYRANNUS.

Four days after hatching (fig. 81) the larvæ have grown to a length of approximately 5.7 mm. Pigment is no longer apparent on the dorsal aspect of the body except near the tip of the tail. A small group of chromatophores occurs in the caudal region, also on the ventral aspect of the body. Black chromatophores are now present in a series along the digestive tube from the level of the pectoral fins to the vent.

In young fish 9 mm. in length the dorsal fin is becoming differentiated. In the posterior abdominal region the intestine is already distinctly convoluted. The distribution of pigment remains essentially as in the preceding stage.

In young fish 23 mm. in length (fig. 83) all the fins are well differentiated. The body remains relatively slender. Black chromatophores now occur superficially on the nape, along the margin of the opercle, near the base of the dorsal, anal, and caudal fins, and in small groups posterior to the dorsal fin and just ventral to the pectoral fins. Black pigmented areas occur internally along the dorsal wall of the abdominal cavity and in a series at the dorsal level of the notochord.

Figure 84 is an illustration of a specimen 33 mm. long. Scales are present, the back is becoming pigmented, there is a distinct lateral stripe of dark pigment, and black chromatophores are present on dorsal and caudal rays. At this stage the fish is more slender than the adult. In a specimen 41 mm. long (fig. 85) the characters of the adult are more apparent. The body is deeper and more heavily pigmented than the preceding, and the black blotch on shoulder is distinct.

POMOLOBUS AESTIVALIS (Mitchill). BLUEBACK, GLUT HERRING.

Spawning.—This species spawns in fresh and possibly in very slightly brackish water. In some localities, at least, the spawning season appears to be an extended one. The reason, in part at least, for this is believed to be that young fish coming to maturity may ripen their eggs at a somewhat later date from the regular run of fish. Among the fish taken during July in small ponds with an outlet to the ocean the majority of the females were spent, a few females and many small males were ripe for stripping, and a considerable number of both males and females were still unripe. Young fish 30 to 60 mm. in length were present in the same ponds in abundance.

Eggs.—The eggs are demersal and somewhat adhesive, semitransparent, and yellowish in color. When water-hardened they are spherical in form with a diameter of approximately 1 mm. (fig. 87). The egg membrane is relatively thick, and its inner surface appears finely corrugated. After fertilization has taken place a relatively large perivitelline space becomes apparent.

Embryology.—The volume of protoplasm in proportion to the volume of yolk is considerably greater in these eggs than in the pelagic eggs already described. In the unfertilized egg the protoplasm is disposed in a layer of uniform thickness investing the yolk sphere. It is distinctly granular in structure; consequently, after fertilization has taken place, the protoplasmic movements involved in the formation of the blastodisc may be readily observed. The fully differentiated blastodisc (fig. 88 BD) is relatively thick and covers a relatively large area of the surface of the yolk sphere. Near the periphery it thins out abruptly and then fades away gradually into the very thin layer of protoplasm that remains at the surface of the yolk. The yolk sphere now shows apparent lines of cleavage that give it the appearance of being broken up into large cells. This structure in the yolk is less apparent in these eggs than in the eggs of *Anchovia* and certain other teleosts.

Cleavage takes place very regularly and in a manner typical for teleostean eggs. The volume of protoplasm being relatively large, the early blastomeres are correspondingly large and show a marked tendency to assume a spherical form (figs. 89 and 90).

As cleavage advances the radius of the blastoderm gradually increases. This peripheral growth of the blastoderm becomes apparent before the periblast is well differentiated (figs. 91 and 92). After the periblast is well formed the blastoderm grows round the yolk more rapidly. When the germ ring is well differentiated the blastoderm covers more than half the surface of the yolk. Figure 93 illustrates an egg in which the germ ring is fully formed and the differentiation of the embryonic shield is well started. The embryonic shield becomes relatively long and narrow. The embryonic axis, when

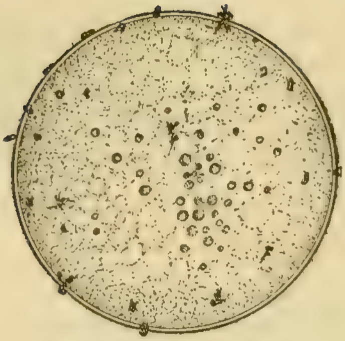

Fig. 87.—Mature unfertilized egg

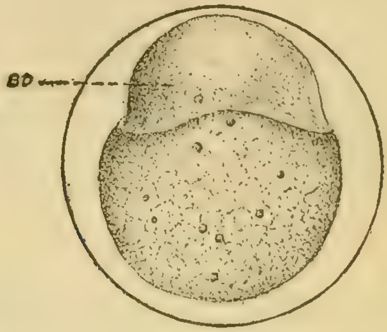

Fig. 88.—Egg with blastodisc (BD) fully differentiated.

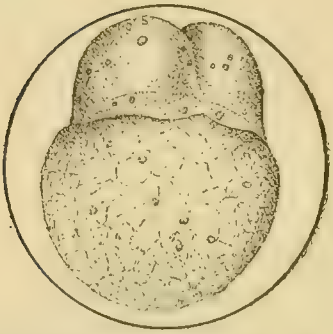

Fig. 89.—Egg with blastoderm of 2 cells.

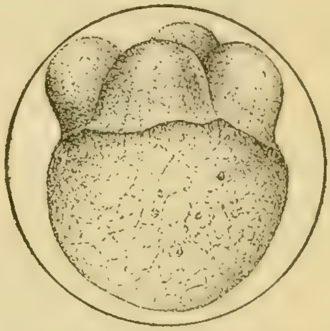

Fig. 90.—Egg with blastoderm of 4 cells.

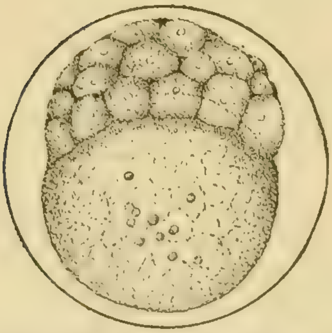

Fig. 91.—Egg with blastoderm of 64 cells.

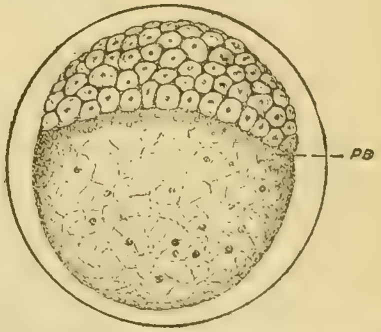

Fig. 92.—Egg with blastoderm in moderately advanced stage of cleavage, early stage in differentiation of periblast (PB).

POMOLOBUS ÆSTIVALIS.

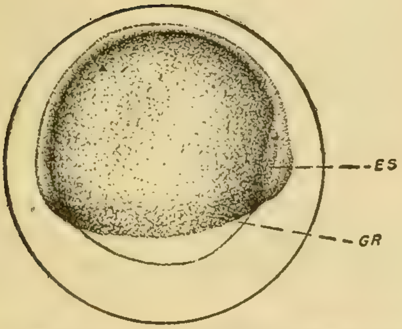

FIG. 93.—Egg showing an early stage in the differentiation of the embryonic shield (ES), germ ring (GR).

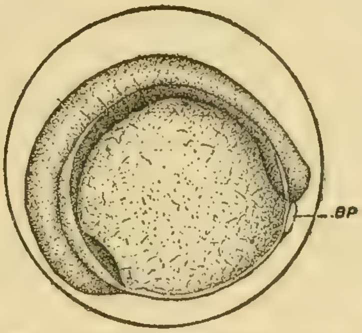

FIG. 94.—Egg with embryo well differentiated, blastopore (BP) nearly closed.

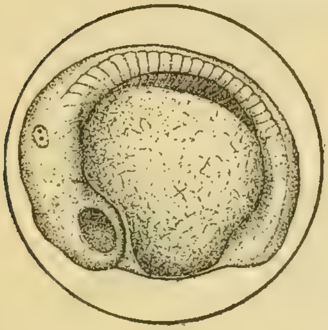

FIG. 95.—Egg with embryo showing 24 to 26 somites.

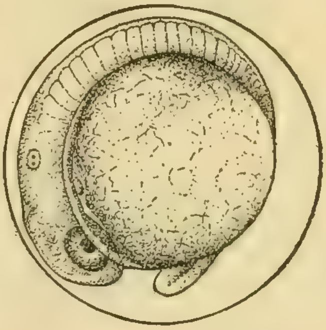

FIG. 96.—Egg with advanced embryo.

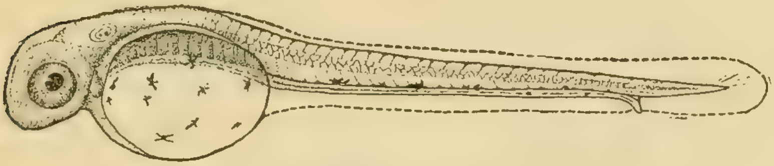

FIG. 97.—Newly hatched fish, actual length 3.5 mm.

POMOLOBUS ÆSTIVALIS.

fully differentiated, extends more than halfway around the circumference of the yolk sphere. Although the blastoderm early covers a large portion of the surface of the yolk, the blastopore does not close until the embryo is well formed and segmentation of the body has begun (fig. 94). The closure of the blastopore occurs within 16 hours after fertilization. At this time the embryo extends fully two-thirds around the circumference of the yolk sphere. Figure 95 illustrates an egg shortly after the blastopore is closed.

As the time of hatching approaches the embryo increases in length until it makes more than a complete turn within the egg membrane. It becomes relatively opaque but shows very little pigment.

Larval development.—Incubation at laboratory temperature occupied approximately 50 hours. The newly hatched larvæ (fig. 97) are approximately 3.5 mm. in length and relatively slender. The head is somewhat deflected at the anterior end of the yolk sac. The vent is located near the posterior end of the body. Black chromatophores occur sparsely scattered over the yolk sac and in a series along the intestine.

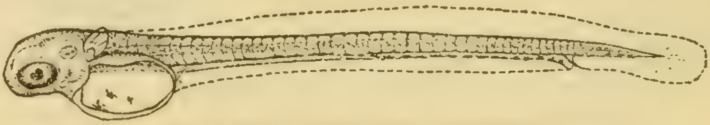

FIG. 98.—Larval fish 1 day after hatching, actual length 4 mm.

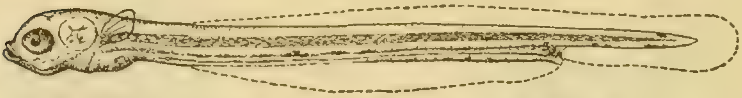

FIG. 99.—Larval fish 4 days after hatching, actual length 5.2 mm.

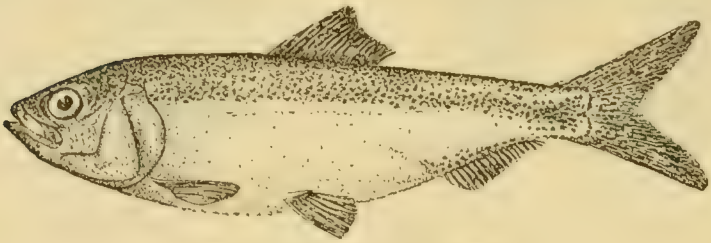

FIG. 100.—Young fish 30 mm. in length.

POMOLOBUS ÆSTIVALIS.

One day after hatching (fig. 98) the larvæ have grown to a length of 4 mm. The greater part of the yolk is absorbed and the head is no longer deflected. The general appearance of the larva has not changed materially, although the series of chromatophores along the intestine has become more marked and a few chromatophores appear at the base of the ventral-fin fold posterior to the vent.

Four days after hatching (fig. 99) the larvæ have attained a length of 5 mm. or over. The yolk is completely absorbed. The distribution of pigment remains essentially as in the earlier stages.

Figure 100 illustrates a young fish 30 mm. in length. Young fish 30 to 50 mm. in length, as indicated above, were present in abundance during July in the waters in which adult fish were found spawning. Young fish of this size have the general appearance of adults and show all the diagnostic characters of the species.

MENIDIA MENIDIA NOTATA (Mitchill). SILVERSIDE.

Spawning.—This species spawns in June and July. The height of the spawning season is reached, doubtless, before July 1. The great majority of the fish taken early in July were already spent.

Eggs.—The eggs are spherical in form, 1.1 to 1.2 mm. in diameter. They are demersal and are held together in ropy clumps by a tangle of adhesive threadlike processes, a tuft of which arises from the membrane of each egg. The yolk sphere contains 5 to 12 large oil globules of unequal size and numerous smaller ones. The larger oil globules may or may not be aggregated; the smaller ones are distributed more or less uniformly over the surface of the yolk. The eggs are yellowish in color and semitransparent. The egg membrane is thick and the micropyle relatively large (fig. 101). These eggs are very similar to those of the related species, *Kirtlandia vagrans*, described in an earlier paper,[a] but are somewhat larger.

Embryology.—These eggs, being somewhat larger and much more heavily laden with yolk material, develop much less rapidly than do the pelagic eggs here described. In all other essential respects their embryological development follows a course practically identical with that as outlined for the eggs of *Tautoga onitis*. Successive stages in the process of cleavage and the differentiation of the embyro are illustrated in figures 102 to 106. The embryo is well differentiated and shows 20 to 24 somites within 40 hours after fertilization (fig. 106).

The beginning of pigmentation is observed during the third day of incubation. Black chromatophores become sparsely scattered over the embryo and the extra-embryonic blastoderm. Yellow chromatophores appear only on the embryo. As development advances, black chromatophores become aggregated in a few areas on the dorsal aspect of the head and in a series at the base of the ventral-fin fold. A few black chromatophores appear at the base of the dorsal-fin fold near the posterior end of the body. The black chromatophores in the extra-embryonic blastoderm gradually become arranged along the extra-embryonic blood vessels. Small yellow chromatophores remain sparsely scattered over the embryo for some time, but gradually become less conspicuous.

Larval development.—Incubation at laboratory temperature occupied 8 to 9 days. The newly hatched larvæ (fig. 109) are approximately 5 mm. in length and relatively slender. The yolk is largely absorbed before hatching. The vent is located just posterior to the yolk sac. From this level the body tapers gradually toward the posterior end. Black and yellow chromatophores are aggregated on the dorsal aspect of the head and in the dorsal region of the abdominal cavity. Black chromatophores are present on the ventral aspect of the yolk sac, in a series at the base of the ventral-fin fold, and in a few small groups at the base of the dorsal-fin fold toward the posterior end of the body.

Five days after hatching (fig. 110) the larvæ have grown considerably, but the majority of them do not exceed 5.5 mm. in length. The yellow pigment is materially reduced. Black chromatophores have become more abundant on the dorsal aspect of the head and anterior trunk region. The body is marked further by a series of black chromatophores at the base of the ventral-fin fold and another at the ventral level of the notochord.

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[a] Kuntz, A.: Notes on the embryology and larval development of five species of teleostean fishes. Bulletin, Bureau of Fisheries, vol. XXXIV, 1914, p. 420.

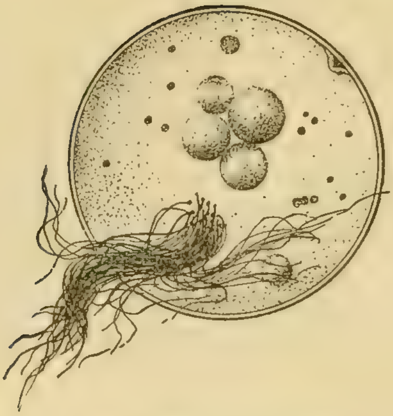

FIG. 101.—Mature unfertilized egg.

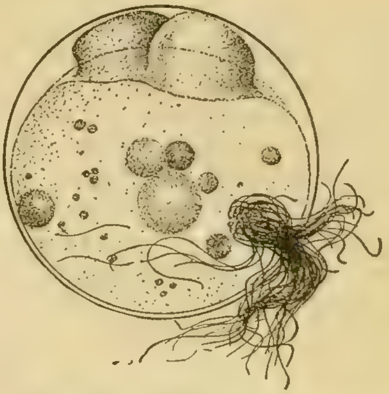

FIG. 102.—Egg with blastoderm of 2 cells.

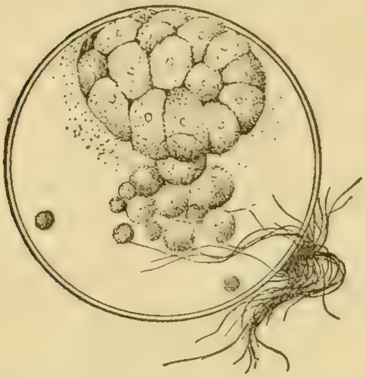

FIG. 103.—Egg with blastoderm of 16 cells.

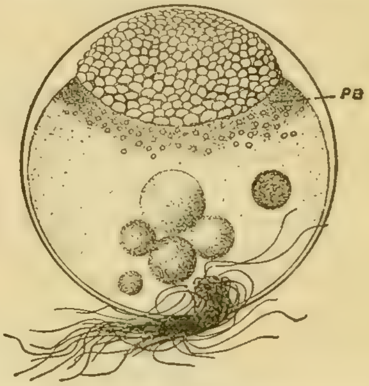

FIG. 104.—Egg with blastoderm in advanced stage of cleavage, periblast (PB) differentiated.

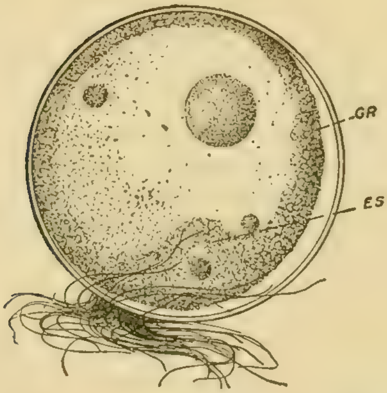

FIG. 105.—Egg showing germ ring (GR) well differentiated and early stage in differentiation of embryonic shield (ES).

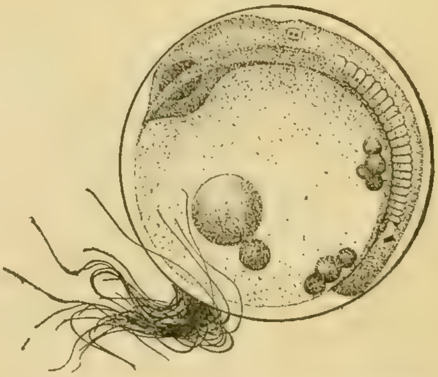

FIG. 106.—Egg showing embryo with 22–24 somites.

MENIDIA MENIDIA NOTATA.

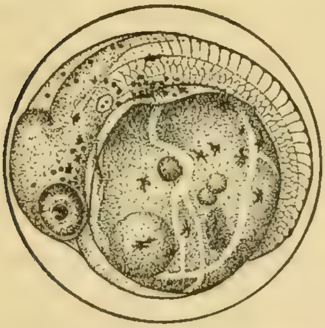

FIG. 107—Egg 6 days after fertilization.

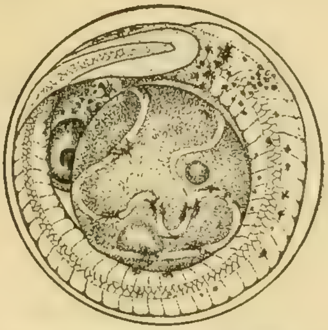

FIG. 108.—Egg 8 days after fertilization.

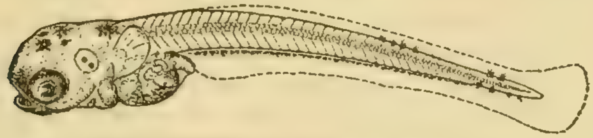

FIG. 109.—Newly hatched fish, actual length 5 mm.

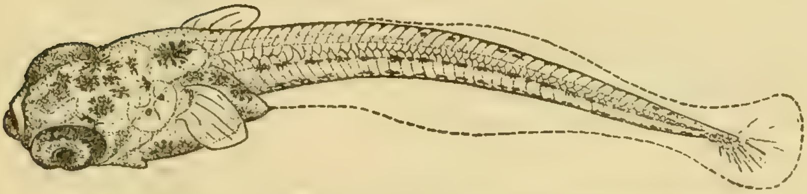

FIG. 110.—Larval fish 5 days after hatching, actual length 5.5 mm.

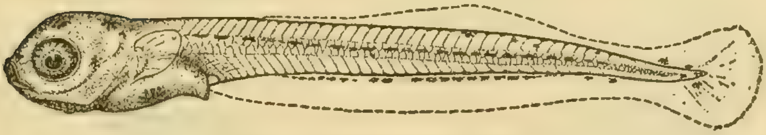

FIG. 111.—Young fish 8 mm. in length.

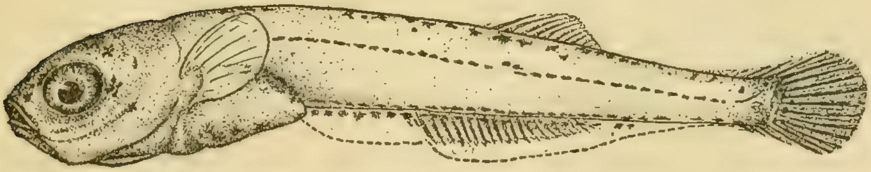

FIG. 112.—Young fish 13 mm. in length.

MENIDIA MENIDIA NOTATA.

Young fish 8 mm. in length (fig. 111) do not differ essentially in their general appearance from the young fish 5 days old just described. The distribution of pigment also remains essentially the same.

In young fish 12 to 15 mm. in length (fig. 112) the distribution of pigment observed in the earlier stages is still apparent; however, black chromatophores are becoming more abundant on the dorsal aspect of the body. The silvery lateral band characteristic of the species is not yet well differentiated. The dorsal, anal, and caudal fins are well formed, and the young fish are gradually assuming adult characters.

GASTEROSTEUS ACULEATUS Linnæus. THREE-SPINED STICKLEBACK.

Spawning.—The spawning season of this species begins in May (Edwards) and continues until late in July. Females ripe for stripping were taken as late as July 24. Males ripe for stripping were not secured. Fertilization was accomplished by macerating the testes of the male in the water into which the eggs were stripped.

Eggs.—The eggs are demersal and adhere firmly in small clumps. They are somewhat irregular in form when stripped from the female, but become spherical as soon as they become water-hardened. If they adhere closely, adjacent surfaces may remain somewhat flattened. They are yellowish in color, semiopaque and have a diameter of 1.5 to 1.7 mm. The egg membrane is thick and apparently smooth, but strongly adhesive, The yolk sphere contains numerous oil globules of unequal size, which are usually aggregated more or less closely. Very minute oil globules also occur sparsely scattered over the surface of the yolk sphere (fig. 113).

Embryology.—The eggs of this species develop typically. The volume of protoplasm in proportion to the volume of yolk is comparatively small; consequently the blastodisc (fig. 114 BD), as well as the early blastoderm (fig. 115), covers a relatively small area of the surface of the yolk. Early development advances quite rapidly. Within 24 hours after fertilization the embryo is well differentiated and the blastopore is closed (fig. 116).

Before the close of the third day of incubation the embryo extends nearly around the circumference of the yolk sphere (fig. 117). The head is relatively broad, and the body tapers gradually toward the posterior end. Circulation may be observed throughout the entire extra-embryonic blastoderm. Small black chromatophores are present on the dorsal surface of the anterior region of the trunk and in the adjacent areas of the extra-embryonic blastoderm.

As the time of hatching approaches, the embryo grows larger and the yolk becomes materially reduced (fig. 118). A close-meshed network of blood vessels becomes apparent over the entire surface of the yolk sphere. Chromatophores have become larger and more numerous. They are now present over the entire dorsal surface of the embryo, in the adjacent areas of the extra-embryonic blastoderm, and in a series along the ventrolateral aspect of the body posterior to the vent.

Larval development.—Incubation at laboratory temperature occupied approximately six days. The newly hatched larvæ (fig. 119) are 4.2 to 4.5 mm. in length. The vent is located a short distance posterior to the yolk sac and more than half the length of the body from the anterior end. The general color of the body is yellowish. Diffuse yellow pigment and small yellow chromatophores occur over the entire body. Large black chromatophores are more or less closely aggregated on the dorsal surface of the body,

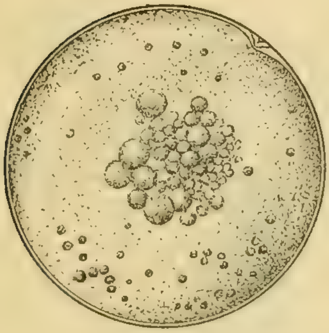

FIG. 113.—Mature unfertilized egg.

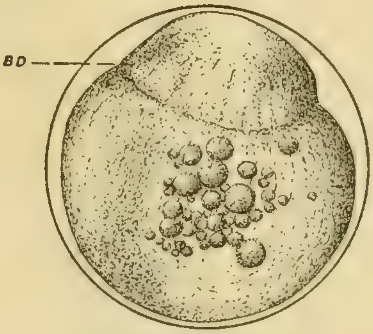

FIG. 114.—Egg with fully differentiated blastodisc (LD).

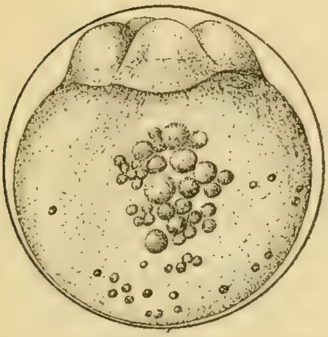

FIG. 115.—Egg with blastoderm of 4 cells.

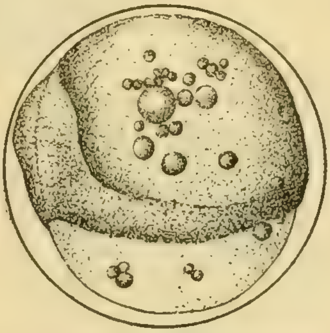

FIG. 116.—Egg 24 hours after fertilization.

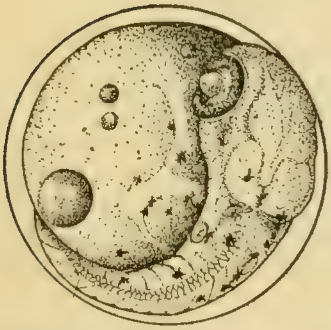

FIG. 117.—Eggs 68 hours after fertilization.

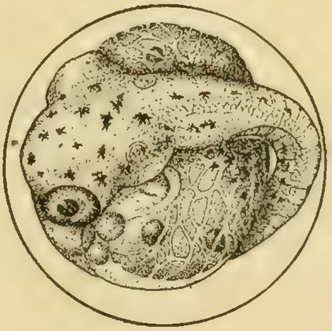

FIG. 118.—Egg 4 days after fertilization.

GASTEROSTEUS ACULEATUS.

on the surface of the yolk sac adjacent to the body, and on the ventrolateral aspect of the body near the base of the ventral-fin fold.

Three days after hatching (fig. 120) the young fish have grown to a length of 6.2 to 6.5 mm. The general color of the body remains yellowish, and the distribution of black pigment remains essentially as in the newly hatched larvæ. However, the chromatophores have increased materially in number.

Eight days after hatching (fig. 121) the young fish have attained a length of approximately 7 mm. The general color of the body is now darker than in the earlier stages. Black pigment has become more abundant, and the yellow pigment is materially reduced. Black chromatophores are present over the entire surface of the body but are closely aggregated only on the dorsal and dorsolateral aspects.

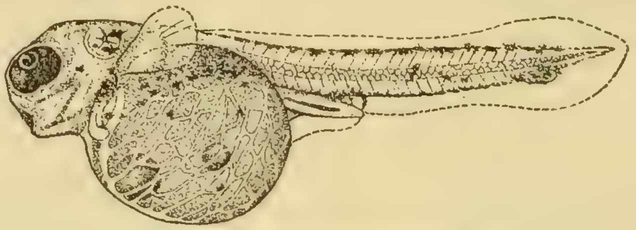

FIG. 119.—Newly hatched fish, actual length 4.3 mm.

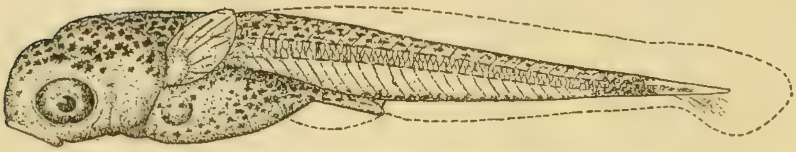

FIG. 120.—Larval fish 3 days after hatching, actual length 6.3 mm.

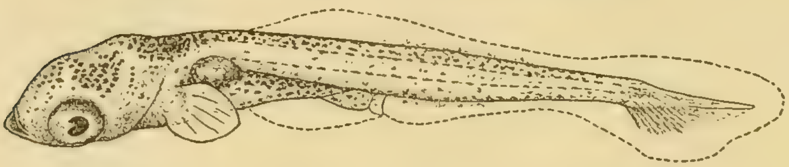

FIG. 121.—Larval fish 8 days after hatching, actual length 7 mm.

GASTEROSTEUS ACULEATUS.

APELTES QUADRACUS (Mitchill). FOUR-SPINED STICKLEBACK.

Spawning.—This species is known to spawn in May and June (Sumner). The spawning season continues until late in July. Females ripe for stripping were taken as late as July 24. A considerable number of females were taken on August 3 but all were spent. As in the case of *Gasterosteus aculeatus*, males ripe for stripping were not secured. Fertilization was accomplished by macerating the testes of the male in the water into which the eggs were stripped.

Eggs.—The eggs are demersal and adhere firmly in small clumps. They are similar to the eggs of *G. aculeatus* here described but more intensely yellowish and consequently more opaque. They are somewhat irregular in form when stripped from

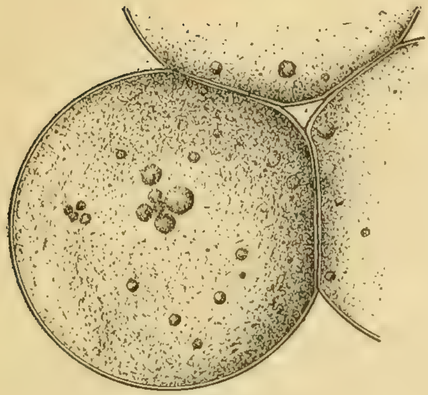

FIG. 122.—Mature unfertilized egg.

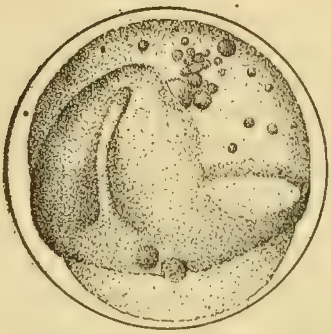

FIG. 123.—Egg showing advanced stage in differentiation of embryonic shield.

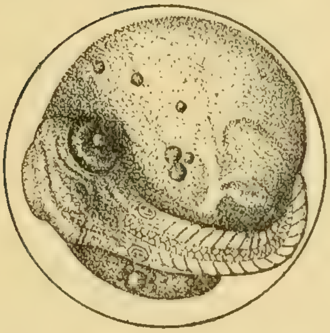

FIG. 124.—Egg 48 hours after fertilization.

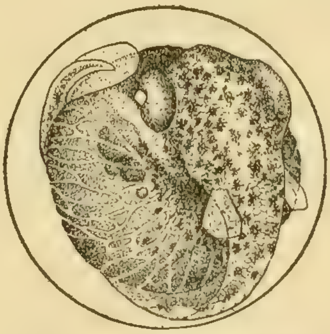

FIG. 125.—Egg 4 days after fertilization.

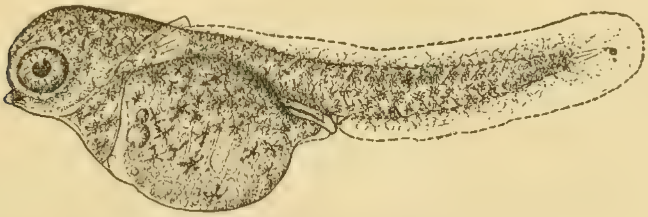

FIG. 126.—Newly hatched fish, actual length 4.3 mm.

APELTES QUADRACUS.

the females but become spherical as soon as they become water-hardened. Contiguous surfaces may remain slightly flattened. The average diameter is approximately 1.6 mm. The yolk sphere contains a few oil globules of unequal size which may be aggregated more or less closely or widely scattered (fig. 122).

Embryology.—The eggs of this species present essentially the same pictures during early embryological development, as do the eggs of the related species *G. aculeatus.* Their development is entirely typical and need not be discussed in detail.

Pigmentation begins relatively early, and pigment is developed rapidly. Four days after fertilization (fig. 125) large black chromatophores are present over the entire surface of the embryo as well as in the adjacent areas of the extra-embryonic blastoderm. Small yellow chromatophores also occur scattered over the surface of the embryo but are not conspicuous.

Larval development.—Incubation at laboratory temperature occupied approximately six days. The newly-hatched larvæ (fig. 126) are 4.2 to 4.5 mm. in length. The vent is located a short distance from the posterior end of the yolk sac and slightly more than half the length of the body from the anterior end. The general color of the body is dark brown. Yellow pigment remains sparsely scattered over the body but is obscured by the greater abundance of black pigment. Large black chromatophores are closely aggregated over the entire surface of the body and the upper half of the yolk sac. The newly hatched fish is similar to the newly hatched larva of *G. aculeatus*, but much more heavily pigmented.

THE OCCURRENCE IN VIRGINIA OF GREEN-GILLED OYSTERS SIMILAR TO THOSE OF MARENNES

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By Philip H. Mitchell and Raymond L. Barney

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Contribution from the United States Fisheries Biological Station, Woods Hole, Mass., and the Biological Laboratory of Brown University

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INTRODUCTION.

The appearance of green-gilled oysters in Lynnhaven Bay, Va., in such large quantities during the fall and early winter of 1915 that several of the oystermen of the vicinity were unable to sell their product because of the dark-colored gills led to this investigation. The problem is of considerable economic interest since the entire oyster industry of Chesapeake Bay was at stake, the green-gilled oysters being found in locations many miles distant from one another. Moreover, if this outbreak could be proved to be an exact reproduction of the greening of the popular Marennes oysters, it might be the basis of oyster culture in Virginia from an entirely new point of view. Further than this, the study offered an interesting scientific problem which narrowed itself down, in the consideration of the writers, to a physiological and chemical study of the pigment and the manner in which the oyster re-acted to it. The main purpose, however, in this study has been to find whether or not the greening of the gills in the Lynnhaven oysters is the same as that in the choice Marennes oysters, for a glance at our American oysters shows that they are very similar in general appearance and in the distribution of the pigment to the descriptions and drawings of the Marennes oysters.

HISTORY.

In the past there has been considerable work done on the green coloration of oysters, especially in Europe. Papers have been written on both the green-gilled and the copper-green oysters.

The genuine green-gilled oyster was first worked on by M. Gaillon, who published his first paper in 1820. In this paper he explained the French custom of placing the oysters in claires or large reservoirs just within the high-tide mark and allowing them to remain there for a considerable length of time or until the gills and palps showed the green tint. He recognized that if the tanks contained a certain diatom, *Navicula ostrearia*, in large quantities, the oysters would take on the green coloration, but that when the oysters were taken from the tanks and placed in fresh sea water, or allowed to remain in the tanks after the growth of the diatoms had ceased, the oysters would arrive gradually at their normal color in three or four weeks. Furthermore, Gaillon pointed out that common chlorophyll was not the coloring matter. His conclusion that the *Navicula ostrearia* was the cause of the greening of Marennes oysters was accepted and corroborated by other European biologists later in the century. Gaillon, however, offered no proof as to how the green substance reached the gills. He noticed that no other organs of the body except the gills and palps were ever colored, but he did not try to show how the coloration took place. He intimated that perhaps the green substance entered the gills through the gill filaments, but he could not offer scientific evidence of such entrance.

Valenciennes in 1841 drew attention to the fact that beside the gills and palps, the liver and intestines often showed a green tint, while the heart, reproductive system, muscles, and blood showed no abnormal color whatsoever.

Gaillon, in a second paper in 1824, suggested what appeared to be the proper explanation of the green colorations in the gills, palps, liver, and intestines by saying that the coloring material is taken into the alimentary canal and that the oyster's gill tissue selects and deposits the coloring matter much the same as the osseous tissue of pigs fed on madder selects and deposits the red coloring of that plant. Thus it will be seen that Valenciennes in 1841 was hardly more than corroborating the work done by Gaillon in 1821 and 1824. Valenciennes, however, did considerable work on the chemistry of the pigment. He found that the coloring material of green-gilled oysters was insoluble in water, alcohol, ether, weak alkalies, or weak acids and that the only reagents that would dissolve the pigment were those that destroyed it forthwith. He, furthermore, came to the conclusion that the green-gilled pigment had no connection whatsoever with any metallic element, thus putting the green-gilled problem in a different category from the copper-green oyster with which it had oftentimes been confounded.

In 1861 Coste brought forth the suggestion that the greening of Marennes oysters was due to iron salts in the soil on the bottoms of the claires. This theory had been advanced several times, but Bornet and Ad. Chatin showed without much doubt that in certain places the oysters in the claires would remain indefinitely white and then, suddenly, would take on the green coloration, due in their estimation to a change in the flora of the park and not because of the fact that the floor of the claire had changed in its elemental composition. Sullivan in 1870 came to the conclusion that green-gilled oysters contained no copper. Dyer in 1877 showed that oysters put in dishes that contained *Navicula ostrearia* became green in 36 hours. Puysegur in 1880 published the results of some of his observations on greengills, mentioning especially that he had turned the gills of normal oysters green by immersing the oysters for only a few hours in water that contained the *Navicula*. Borney, Ducaisne, and others observed the same results from similar experiments.

In 1886 Ray Lankester, the eminent English biologist, affirmed the work of Valenciennes as regards the absence of any metallic compound in the green pigment that caused the gill coloration. In this paper Lankester made it his purpose to demonstrate three things:

1. That the oysters do swallow the *Navicula ostrearia*.

2. That a pigment having the same peculiarities determined by Valenciennes, or from which Valenciennes's pigment could be derived, actually occurs in the *Navicula ostrearia*.

3. That there is some mechanism in the oyster by which the pigment of the *Navicula ostrearia*, being taken into the oyster's alimentary canal, can be absorbed and deposited in the gills and palps.

These points Lankester well brought out. He concluded, through the fact that he found many frustules of the diatoms in the intestines and stomachs of green-gilled oysters, that they must have swallowed them. Further than that, he observed the pigment of the *Navicula ostrearia* chemically and spectroscopically and found it to have exactly the same properties as the green pigment of the Marennes oyster. Lankester also did considerable work on the histology of the oyster gill in an effort to find and demonstrate the exact distribution of the pigment. This distribution of green material he found to be in amœboid leucocytes that work their way through the epithelial cells of the gills and move around on the external surface of the gills. These cells he called "secretion cells," and they are found on all normal oyster gills. With this work Lankester also published a minute description and a set of colored drawings of the *Navicula ostrearia* and the distribution of its pigment throughout the oyster.

In 1899 Herdman and Boyce, two English investigators, published a paper on "Oysters and Disease," in which they drew attention to the fact that copper-green oysters and green-gilled oysters were two different abnormalities. This paper was merely a review of the work that had been done on the green oysters up to that time, supplemented by a study of the histology of the two different types of green abnormality. Ryder, whose work has been published in several United States Fish Commission reports, did much investigation on green oysters, but the copper-green oyster received his attention especially.

The only papers dealing with the conditions that show the effect environment may have on the growth of the *Navicula ostrearia* and the consequent greening of the oysters are those by Boubés and Calvet. Boubés, in his "L'ostreiculture à Arcachon," gives a general survey of natural, legal, and economic conditions affecting the oyster industry at Arcachon, contrasting these with circumstances at Marennes. In this publication he mentions the most important fact that, when the claires are allowed to get too salt, the product, the greengill, is not so good. He intimates in this statement that a high specific gravity is not conducive to the life of *Navicula ostrearia*. Calvet, 1910, in "Du Vertissement des Huitres," discusses the conditions that tend toward an optimum "greening" of oysters left in the claires, taking into consideration the temperature, the specific gravity of the water, the depth of the water, the nature of the bottom, and the effect of light on the growth of the *Navicula ostrearia*, and therewith the greening of the gills.

THE GREEN-GILLED OYSTERS OF VIRGINIA.

The oysters found to possess this abnormal condition in Virginia were the large typical Chesapeake oysters. The gills at the height of the epidemic showed a green color, which extended in many cases up into the palps, turning them, also, a greenish color. The liver appeared a somewhat darker brown than in the normal oyster, but the rest of the oyster's body seemed perfectly normal. The larger number of the oysters observed were in a well-nourished condition and appeared very "fat." Indeed, the people in the vicinity of Lynnhaven used them freely, claiming that they possessed a more delicate flavor than the ordinary white oyster. The oyster dealers of the place also shipped considerable quantities to distant destinations where, according to reports, they received ready sale.

The epidemic itself was spread over large areas, which, in some cases, were many miles distant from one another. Lynnhaven Bay, with the two large creeks that combine to form it, was the seat of the most serious outbreak at the time of this study. The same location had been reported to have suffered in a like manner in 1912. From testimony taken from various oystermen of Hampton and Phoebus, greengill had appeared at different dates, but all who were interviewed agreed that the last general epidemic occurred in 1912. At that time the greengill was distributed the entire length of Hampton Bar and Flats from Newport News to Phoebus and Mill Creek, and both the northwest and southwest branches of Back River also suffered. The present outbreak again affected Mill Creek and both branches of Back River. Farther north and more on the open coast greengill was found in considerable quantity on Drum Island Flats, but Hampton Bar and Flats at the time of this investigation were free of the epidemic. It was learned, however, that oyster beds from Cobbs Island down to Goodwins Island had suffered in various years and at various locations from greengill.

An effort was made in taking these data to get general information from those interviewed in regard to weather conditions, temperature, depth of water, and general locations of outbreaks with their relationship to the greening, but with little success. The theory offered by one individual would be contradicted by the next person interviewed, so that no facts or ideas common to all observers were obtained from those most closely connected with the oyster industry.

Not being able to gain specific knowledge of the general relationships of greengill with weather, temperature, salinity, etc., from interviews, and at the same time trying to find some connection between the true Marennes green-gilled oyster and the greengill at hand, it was decided to take water samples from locations where the epidemic was prevalent and observe the temperature, salinity, and the vegetable life in the water. Samples thus studied were taken on January 4, 5, and 6, 1916. The weather of these days was rainy or cloudy, with the temperature varying from the freezing point to about 15° C. The water samples were taken from places where the water was not more than 6 inches deep and which, therefore, was open to a considerable change of temperature during the day and night. No doubt the temperature of the water during the night lowered to within 2 or 3° C. of freezing, while during the day it increased to perhaps 12 or 13° C. For about a week before these samples were collected, there had been a heavy storm blowing from the southeast, and the bottoms of Lynnhaven Bay and the coves, which up to the time of the storm were reported to be covered with a green carpet of vegetable life, showed nothing but the typical gray clayey mud with the water very much roiled. Samples were taken, however, and in five of the six samples obtained in various parts of Lynnhaven Bay diatoms were found that exactly answered the description of the *Navicula ostrearia* as set forth by Lankester. The temperature of the water ranged from 10 and 11° C. in shallow places to 5 and 6° C. in the deeper water. The specific gravity of the samples varied from 1.018 to 1.019. The results of this collection were as follows:

Location.	Temperature.	Specific gravity.	Navicula ostrearia present.	Location.	Temperature.	Specific gravity.	Navicula ostrearia present.
	°C.				°C.		
Opposite Croonenbergh's oyster house	11.3	1.018	Yes.	Croonenbergh's cove			Yes.
Croonenbergh's claire	10.0	1.019	Yes.	Opposite Fentress's crab pound			Yes.
Cove at Willard Diggs	5.6	1.018	Yes.	Fentress's crab pound			No.

Other observations on specific gravity and temperature were recorded as follows:

Location.	Temperature.	Specific gravity.	Tide.	Location.	Temperature.	Specific gravity.	Tide.
	° C.				° C.		
Near oyster house	5.0	1.019	Rising.	Beginning of east branch	6.0	1.019	Rising.
Middle of east arm	6.0	1.019	Do.	Midway up east branch	6.5	1.019	Do.

At the same time with these observations, examinations were made of the contents of the stomachs of several oysters just taken from Croonenbergh's Bar, and in every case diatoms or the frustules of diatoms were found that were of exact description of the *Navicula ostrearia.*

In a similar manner, as at Lynnhaven, the water of Back River was studied. Whereever a water sample was taken, oysters were dredged and in every case showed the greengill. The weather there was the same as had been experienced at Lynnhaven, and the water was very much roiled. The specific gravity and temperature of the water varied from 1.015 to 1.017 and from 8.5 to 10° C., respectively. In the five samples taken, approximately half a mile apart, two contained diatoms which were identified as *Navicula ostrearia.* The observations in Back River were as follows:

Location.	Specific gravity.	Temperature.	Navicula ostrearia present.	Location.	Specific gravity.	Temperature.	Navicula ostrearia present.
		° C.				° C.	
Creek south of Hampton Institute Farm	1.017	9.0	No.	Cove opposite Hampton Farm	1.015	9.5	Yes.
Sherwood Farm	1.016	10.0	Yes.	North of Sherwood Farm, near shore	1.0165	8.5	No.
Creek on opposite side	1.015	9.5	No.				

The *Navicula ostrearia* was also found in the green scum that clung to the shell of one of the oysters dredged in this observation.

On January 19, 1916, a sample of water from the western arm of Lynnhaven Bay, Va., was examined after a two days' shipment during very cold weather. The sample, despite the cold weather, yielded many different kinds of vegetable organisms, among which was observed the *Navicula ostrearia.* On February 18, 1916, a water sample from Lynnhaven Bay was examined that showed by far a larger number of organisms with the characteristic *Navicula ostrearia* appearance than any water sample yet taken. On March 17 another water sample was received from Lynnhaven and examined, but this showed no *Navicula* organisms whatsoever. Possibly this absence of the abovementioned organisms was due to the fact that the sample was taken in deeper water and with a large bottle that had a very narrow neck. The shape of the bottle was in itself enough to prevent obtaining an average and acceptable sample. On April 17, 1916, another water sample from Lynnhaven arrived and was examined. This, however, showed no *Navicula*, but the absence on this occasion of the diatoms could be reasonably laid to the report that the greengills were clearing up in the bay and that no very green oysters could be found. Those which did have any pigment were very pale. On June 14, 1916, a similar water sample was examined, but this showed no *Navicula ostrearia.*

In an effort to ascertain whether the *Navicula ostrearia* inhabited the waters where the greengill had never been known to exist, and to further the theory that the blue diatom caused the greening, Narragansett Bay was studied in a general way with respect to its diatom growth. In samples taken in different parts of the bay and in sheltered locations along some of its inlets no diatoms that in any way answered the description of *Navicula ostrearia* were found. Further than that no classification of American diatoms that could be obtained gave any description of a *Navicula* of the characteristics that were typical of the organism found in the southern waters.

Following are the results of the examination of water samples from Narragansett Bay:

Location.	Specific gravity.	Temperature.	Navicula ostrearia present.	Location.	Specific gravity.	Temperature.	Navicula ostrearia present.
		°C.				°C.	
Seekonk River		4	No.	Crescent Park Bridge	1.014	4	No.
Warwick Cove		7	No.	Dodge's oysterhouse	1.011	3	No.
Shawomet Beach Cove		6	No.				

The examination of the alimentary canal of 13 oysters with greengills which arrived some three or four days after shipment from Virginia showed in every case the presence of *Navicula ostrearia* frustules in the digestive tract. In 8 oysters the stomach contents were examined; in 3 the intestines were opened and their contents examined; while in the 2 others excrement was obtained from the rectum and in every case the presence of the sought-for frustules was determined.

NAVICULA FUSIFORMIS var OSTREARIA.

Lankester describes the *Navicula fusiformis* var. *ostrearia*, as a minute spindle-shaped diatom which measured about $\frac{1}{270}$ of an inch in length and $\frac{1}{7300}$ of an inch in breadth. It has two long and relatively large yellow-brown endochromes stretched out parallel to the surface of the organism, while at the tip ends, or scattered sometimes throughout the length of the organism, was a pale blue-colored protoplasm. The *Navicula* has a centrally located nucleus and several vacuoles located at intervals along its length.

The organism found in Virginia compares almost exactly with this description. Its measurement, obtained in this investigation, was about $\frac{1}{200}$ to $\frac{1}{300}$ of an inch in length, while in breadth at its broadest point it was found to be between $\frac{1}{2000}$ and $\frac{1}{2500}$ of an inch. In only this one particular are the observations at variance with Lankester's, but it is believed that either his drawings are not proportional to his measurements or there has been some typographical mistake in stating that the width of the organism at its greatest breadth is $\frac{1}{7300}$ of an inch. Indeed, that measurement would mean that the organism was about 3 micra in diameter, which is absurdly small. The mistake is believed to be one of typography and not of scientific inaccuracy, since Lankester's drawings show the length and breadth relationship of his organisms to be exactly what was observed in the diatoms of the Virginia epidemic. The two endochromes, yellowish-green in color, were exactly analogous to those which Lankester deals with in his paper, while the blue protoplasm was also found in analogous locations, usually in the tip ends, but sometimes distributed throughout the entire length of the diatoms. Under changes in osmotic pressure the blue pigment, as well as the yellow-green endochromes, was affected. The blue pigment, which under ordinary conditions was held near the ends of the diatom, was freed suddenly from its location. It was diffused sometimes throughout the body of the organism and at other times it appeared in tiny droplets floating around inside the diatom. The green endochromes, sometimes one and sometimes both, often became twisted and curved out of their normal symmmetrical positions during osmotic changes and gave the diatoms an unbalanced appearance. The nucleus was always centrally located and under normal conditions was surrounded by a mass of transparent protoplasm. The vacuoles were located at intervals along the length of the organism. Observations on the size of the *Navicula ostrearia* were as follows: Length, 131, 99, 93, and 128 micra; width, 12.8, 9.6, 9.1, and 11.6 micra.

The frustules of the *Navicula ostrearia* found in the Chesapeake answer perfectly the descriptions given of the frustules of the Marennes *Navicula*.[a] They show a thick and distinct raphe with a valve difficult to distinguish. At a glance they appear smooth without transverse striæ, these being scarcely visible. The appearance of the Virginia *Navicula ostrearia* compares exactly with that of the European diatom as set forth in Van Huerck's classification, "A Treatise on the Diatomaceæ."

HISTOLOGY OF THE GREENGILL.

In order to study the distribution of the green pigment in the gills, histological sections were cut and examined microscopically. The method followed was simply to kill the tissue in $HgCl_2$, and then run it up through soft and hard paraffin, cut, and finally stain with differential stains. Haidenhain's hematoxylin and eosin or orange G seemed to answer the purpose very well. It was found that the pigment was localized in relatively large, irregularly shaped cells which gave a granular green appearance. These cells did not react to any stain to give a coloring to them but remained green under all conditions. The pigment looked somewhat darker green after staining than it appeared in smears of the gill unstained, but this was probably due to a slight darkening that Haidenhain's had on the pigmented cells or because of the surrounding tissue which was stained very darkly. The location of these cells was in the epithelial tissue of the gill filaments and along the epithelium which lined the interlamellar water space, especially in the vicinity of the interlamellar junctions. The appearance and location of these green cells exactly coincides with the description that Lankester gives of his "secretion" cells.

White gills of Narragansett Bay oysters were studied histologically by the same methods that were used in the greengill study. These showed exactly the same distribution of the large, irregular-shaped cells with granular protoplasm. These, however, were stained by orange G or eosin. The location and appearance of these cells were the same as of the pigmented cells in the greengills. This demonstrated that secretion cells were always present in and on the gills. Lankester said that these cells "furnish precisely the mechanism which we should expect to find in order that the blue pigment absorbed by the blood of the oyster from the contents of the alimentary canal, namely, from ingested *Navicula ostrearia*, should be deposited at a particular spot on the animal's body. These secretion cells do not occur on other parts of the external surface of the oyster. They are limited to the surface of the branchiæ and to the adoral surface of the labial tentacles."

This selection and deposit of a pigment in a given tissue has been likened, as was formerly mentioned, to the deposition of the red color in the osseous tissue of pigs fed on madder. There is the same analogy found in experiments in which canaries are fed cayenne pepper, a diet which if continued will turn the wings a dark orange color.

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[a] **Dr. Albert Mann has examined some of the material and has confirmed the authors' identification of the Chesapeake diatom as *Navicula ostrearia*.**

Another analogy to the selective power of the blood cells in green-gilled oysters is the selection by certain secreting organs in other animals. Palmer and Eccles have shown that cows fed on carotin will eliminate the pigment through the milk. More than that, they have proven that the carotin will be selected by fat cells and in this form will be received into the milk.

The kidney cells in all mammals also have a selecting power in separating out certain urine pigments which are later eliminated in the urine. The secretion cells in the oyster doubtless manufacture mucin under ordinary conditions, and probably in the exercise of this function dispose of the green pigment if the oyster again becomes colorless.

In a continuance of the microscopic study of the greengill, smears were made of the teased tissue of the pigmented gills. These showed the presence of the pigment in large irregularly shaped cells, the granular cytoplasm being distinctly green. These cells moved about in a typical amœboid manner, which led to the conclusion that possibly the secretion cells were nothing more than leucocytes. Smears of this gill tissue were compared with smears of white gills, and in each case the characteristic amœboid leucocytes appeared. Wright's bloodstain was then used on several smears, and in each case the green leucocytes stood out green against those of the white gill, which stained red with the eosin of the stain.

To prove that the *Navicula ostrearia* was the actual cause of the greening, an attempt was made to develop greengill in a normal white oyster taken from Narragansett Bay, where the greengill has never been known. The oyster was placed in aerated sea water which contained the *Navicula ostrearia.* After a week's time the oyster was examined and showed a pale green color in its gill tissue. To further prove that deposits of green pigment had occurred, smears were made of the gill tissue, and in each case they showed the characteristic green amœboid cells. Experiments to substantiate this study would have been continued, but the water samples subsequently obtained from Virginia were never very rich in diatom growth, and such efforts on the water samples received seemed futile. A control, however, was run on this greening experiment by placing an oyster from Narragansett Bay into aerated sea water from Virginia which contained no *Navicula ostrearia.* After a week's time this oyster was examined and showed no green coloration whatsoever. The secretion cells examined in a smear of the gills were normal in appearance.

The fact that green-gilled oysters depended on the presence of blue diatoms in considerable quantity, and the fact that the water samples from Virginia contained very few of the desired *Navicula* with which to carry on greening under controlled conditions, suggested the possibility of growing the *Navicula* in artificial culture media. Efforts, however, were all with negative results. Several culture media were tried at different temperatures, but none seemed to help in cultivating the organism. The solutions tried as media for the artificial cultivation of the diatoms were as follows:

1. Unfiltered sea water, sp. g. 1.014.
2. Filtered sea water, sp. g. 1.014.
3. Filtered sea water, sp. g. 1.014, 1 per cent lactose broth.
4. Filtered sea water, sp. g. 1.014, 1 per cent dextrose broth.
5. Filtered sea water, sp. g. 1.014, 1 per cent oyster broth.
6. Filtered sea water, sp. g. 1.014, 1 per cent ammonium nitrate.
7. Filtered sea water, sp. g. 1.014, 1 per cent ammonium chloride and sodium phosphate.
8. Filtered sea water, sp. g. 1.014, 1 per cent urea.

[a] 9. Artificial sea water, 1,000 cc. of H_2O, 25 gr. of NaCl, 1 gr. of $MgSO_4$, 5 gr. of $CaCl_2$, 1 gr. of NaBr.
[a] 10. Artificial sea water, 1,000 cc. of H_2O, 1 gr. of HNa_2PO_4, 15 gr. of NaCl, 1 gr. of NaBr, 1 gr. of $CaCl_2$.
11. Artificial sea water, same as No. 9, with straw and moss added.
12. Artificial sea water, same as No. 10, with straw and moss added.

One set of these solutions was kept at room temperature and another at approximately 26° C.

The solutions which contained the dextrose, lactose, and oyster broths were sterilized to prevent too flourishing bacterial growth. The broths here mentioned were those used in bacteriological work.

These solutions were then inoculated with a considerable quantity of diatoms of different species, but in no case did any reproduce, though some lived at least three days in the new environment.

From observations of the water samples from Virginia it was noted that continual slight motion of the water sample and aeration tended toward prolonged life of the diatoms.

Further experiments on the isolation and artificial cultivation of these and other diatoms are projected.

THE CHEMISTRY OF GREEN-GILLED OYSTERS.

The only chemical work that had been done on the green pigment of Marennes oysters at the time of this investigation was summed up in Lankester's work. That work shows that the pigment was insoluble in water, dilute acids, dilute alkalies, alcohol, ether, glycerine, and benzol, either hot or cold, and that the coloration was not due to the presence of copper or any other metallic element. It shows further that strong acids or alkalies dissolved but at the same time destroyed the pigment.

Lankester examined spectroscopically green-gilled tissue with the use of a powerful ray of light. He found, however, that this demonstrated no isolated absorption bands in the spectrum. He also examined in like manner a mass of *Navicula ostrearia*, but detected no absorption bands in the spectrum.

The first investigations in this problem carried on in respect to the chemistry of the greengills was to ascertain whether or not there was any copper present in the gills. Four grams of desiccated greengill were digested in sulphuric acid and potassium nitrate. After complete digestion, and after making the solution ammoniacal, only the faintest trace of yellowish-green color could be detected. This test showed the absence of all but the faintest trace of copper, which has been found to be present in all oysters. This experiment was repeated with the same result. Lankester said in this connection: "Whilst there are so many considerations which explain the origin of the notion that copper may be responsible for the green color of the 'huitres de Marennes,' although that metal has nothing to do with it, it is extremely remarkable as a coincidence that of late years it should have been established that copper in minute quantities is a normal constituent of the blood of molluscs." Further evidence that the greengill contained no abnormal amount of copper was seen in the fact that the people of the vicinity who ate the oysters raw in considerable quantities noticed no abnormal taste. Surely had the green color been due to a copper compound, there would have been enough present in specimens so intensely pigmented to have given the so-called coppery taste that many observers claim is characteristic of oysters containing excessive copper.

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[a] 9 and 10 contained also a considerable quantity of dead diatom material.

The solubilities of the pigment were then studied, using the green-gilled tissue as freshly taken from the living oyster and the tissue after it had been thoroughly dehydrated. The gills of several oysters extracted in alcohol, 95 or 100 per cent, gave a slight yellowish-green coloration to the extract. A carbon disulphide extract of greengills yielded also a yellow-colored solution. But when either one followed the other the second was always somewhat paler. The gills, however, always remained green after such extraction, showing that the green pigment was insoluble in carbon disulphide or alcohol. White oysters yielded the same results. So it appears that these extractions were merely dissolving a pigment common to any oyster gill, probably a lipochrome. A yellow carbon disulphide extract was evaporated down and left a yellow residue that was insoluble in water. This residue was mixed with oil and subjected to the Crampton-Simon test for the detection of carotin. The result was negative. Chloroform and ether were also turned a yellow color when used to extract the greengill, but as in the case of other solvents, the extract did not differ from that obtained from normal oysters.

In dehydrating the green-gilled tissue, the following reagents were used in the order mentioned: Alcohol, ether, and carbon tetrachloride. This method always left the carbon tetrachloride slightly yellow colored and gave a dark green residue of dried gill tissue. This dehydrated tissue was then ground and used in solubility tests that followed. The solvents in different strengths of alkali and acid were used, with the following results:

ALKALI.

0.1, 0.2, 0.3, 0.4, 0.6, 1.2, 1.5, 3, and 6 per cent potassium hydroxide; no pigment dissolved. Material from greengill swelled up into a flocculent gelatinous mass with unchanged color. The supernatant fluid gave an opalescent appearance, but there was no solution of the pigment.

12, 30, and 60 per cent potassium hydroxide; decomposed green-gilled material, leaving a greenish-brown residue.

The same results were detected when the solutions were kept at room temperature during 24 hours or when boiling solutions were used during short periods.

ACID.

0.01, 0.05, 0.1, 0.2, 0.4, 0.6, 0.8, 1.2, 2, 2.5, 3, and 3.5 per cent hydrochloric acid; no action noticeable.

4, 7, and 15 per cent hydrochloric acid; slight yellowish-green coloration, but green-gilled material remains unchanged.

18 per cent hydrochloric acid; disintegrated tissue and turned black.

In the last four strengths of acid recorded, probably disintegration was taking place, while actual dissolving of the original pigment did not occur.

The above results on acids were detected when the solutions were either hot or cold, or when the pigment was allowed to remain in the solution for a period of 24 hours. The same results were observed when alkalies were used. Hot or cold water did not dissolve the green pigment.

After the pigment had been shown to be insoluble in the common solvents, experiments were undertaken to ascertain if there was any chemical combination of the pigment with a protein or fat molecule. In the investigation on this point, green-gilled tissue was subjected to a gastric digestion first, by putting several gills into a 0.2 per cent acid solution of pepsin and allowing the digestion to go on for three days at 37° C. On the third day the digestion was examined, and a small amount of green material was found as a residue, while the liquid had a greenish opalescense. This liquid was filtered off, and the green substance was subjected to a number of different solvents, both hot and cold, but the pigment still remained insoluble in all reagents used.

The solvents tried after gastric digestion were: Alcohol, water, 2 per cent sodium chloride solution, ether, chloroform, carbon disulphide, toluene, carbon tetrachloride, acetone, ethyl acetate, 0.5 per cent sodium carbonate, 12 per cent sodium hydroxide, 0.2 per cent hydrochloric acid, and 12 per cent hydrochloric acid.

The green residue of this digestion was then placed in a pancreatic digestion with the addition of a number of other green-gilled tissues. This digestion was carried out by adding a small amount of tested pancreatin to a 0.5 per cent sodium carbonate solution, and allowing the green material to remain in this for three or four days at 37° C. The result in this case was very similar to the gastric digestion, a green residue remaining with a greenish-opalescent supernatant solution. After filtering and washing the residue with distilled water, the green pigment was still found to be insoluble in the solvents used, whether at boiling or room temperature.

The following solvents were used after the pancreatic digestion: Alcohol, water, sodium chloride, 2 per cent; ether; chloroform; carbon tetrachloride; carbon disulphide; toluene; acetone; ethyl acetate; sesame oil; olive oil; glycerol; cottonseed oil; linseed oil; paraffin oil; gasoline; acetic acid, 0.5 per cent; lactic acid, 1 per cent; lactic acid, 0.5 per cent; salicylic acid; and sodium carbonate, 0.5 per cent.

Putrefaction destroyed the pigment slowly. A solution containing several green-gills allowed to putrefy gave a dark green color to the liquid. Green oysters allowed to die and putrefy showed that the gills turned black, or a very dark green, and finally were thoroughly destroyed, leaving a black mass of foul-smelling organic matter.

The green residue of a pancreatic digestion was then subjected to saponification in a 1 per cent alcoholic sodium-hydroxide solution. This solution was made by distilling absolute alcohol over potash until a distillate was collected that was free from all impurities that might give a yellow color with alkalies. This distillate was then made into a 1 per cent solution of alcoholic sodium hydroxide, using chemically pure sodium hydroxide. The green pigment material was thereupon allowed to saponify by boiling two hours, after which the solution was filtered. The saponification yielded a yellow-colored solution. This was neutralized with hydrocholoric acid with the resulting precipitation of sodium chloride. This solution was then evaporated down to about 10 cc., filtered, and studied spectroscopically.

As a control on this experiment, a like quantity of normal gills was subjected to a similar pancreatic digestion. The solid matter that remained after a three days' digestion was then saponified for two hours at boiling temperature in a 1 per cent alcoholic sodium-hydroxide solution prepared as above. The resulting solution was very nearly colorless, and after neutralizing, filtering, and evaporating, only a suggestion of yellow color could be detected.

The spectroscopic examination of the green-gilled saponification showed an absorption band covering the violet end of the spectrum. Examination of the normal gill material obtained from saponification showed no shadows whatsoever in the spectrum.

To establish the fact that the green coloration of the gills in Virginia oysters was not due to the presence of a bacterial pigment, the pigmented gills were subjected to bacteriological examination.

Small pieces of the pigmented gill were placed in sterile water and shaken up thoroughly and then plated out on nutrient agar in Petri dishes, with the usual bacteriological technique. No color-producing organisms were obtained in three trials. Abundant colonies of white bacteria were observed.

CONCLUSION.

The investigations seem to warrant the following conclusions:

1. The Chesapeake green-gilled oyster is the same as the so-called Marennes oyster.[a]

This conclusion is reached since the Virginia oyster corresponds exactly to the descriptions of the Marennes oyster in general appearance and in microscopic examination. The greengills and palps of our southern oyster coincide precisely with the descriptions and drawings of the French oysters, and the method of distribution by secretion cells and the location of the pigment in definite tissues of the gills, as explained by Lankester, is the same as has been found in these observations of the Lynnhaven oyster. A diatom answering the same description as the *Navicula ostrearia*, recognized as the cause of the greening of Marennes oysters, has been identified wherever green oysters were found in the Chesapeake. The frustules of the diatom have also been obtained from the intestines of the green oysters in this observation exactly as Lankester noted in his study of the Marennes oyster. Again, this investigation agrees thoroughly with the conclusions of several European workers that the pigmentation of the gill can occur by allowing the oyster to remain in sea water in which there are *Navicula ostrearia*, but that there is no coloration if the *Navicula* are absent.

The observations in this investigation on the chemistry of the pigment of Chesapeake green oysters are exactly the same as those made on the Marennes greengills by Lankester. The extreme insolubility of the pigment noted by this investigator as characteristic of the European oyster is in direct harmony with the studies recorded in this investigation.

2. No evidence that the coloration of the gills of Chesapeake green oysters was due to bacteria was found in the investigation.

3. The pigment found in the greengills of Chesapeake Bay oysters yields a saponification product that shows an absorption band covering the violet of the spectrum.

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[a] This statement must be understood as referring to the color and its cause, the only subject treated in this paper. European oysters, as is well known, are not of the same species as American oysters. Marennes oysters in Europe are prized above others, because of the excellent qualities associated with the green-gilled condition. This paper shows that the green-gilled condition in American oysters is identical with that in the oysters of Marennes.

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NUTRITION OF OYSTERS: GLYCOGEN FORMATION AND STORAGE

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By Philip H. Mitchell

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Contribution from the United States Bureau of Fisheries Biological Station, Woods Hole, Mass., and the Biological Laboratory of Brown University

NUTRITION OF OYSTERS: GLYCOGEN FORMATION AND STORAGE.[a]

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INTRODUCTION.

More and more the difficulties of producing well-nourished oysters for market are prone to increase. The continued increment of population along the seaboard causes ever greater pollution of those waters especially suitable for the "fattening" of oysters. Not only does the fresher water of bays and inlets increase the meats of oysters by causing osmosis of water into the tissues, but the actual food for oyster fattening in the true sense tends to be more abundant in such waters. Modern sanitary limitations to oyster culture have therefore made it important to the industry that further information concerning food for oysters and the conditions under which they can be made to yield larger amounts of marketable meat be obtained by investigation. The present paper is one step in that direction.

Chemical analysis of oyster meats would seem to offer the only reliable method of estimating the food value of oysters, since the size and weight of either the entire oyster or the "shucked" meats depend so much on the relative amounts of inorganic matter present as shell and sea salts and on the relative amount of water present that the food value is not truly shown. Estimations of glycogen in the oyster promised an especially fruitful method of studying changes in its nutritive condition, because this substance may constitute the most abundant single constituent when present to the extent of 20 or 25 per cent of the dried meats and because it is subject to very great and comparatively rapid fluctuations in amount. The actual variations in glycogen must be distinguished, of course, from the percentage changes caused by differences in water and salt content of the oyster. It was necessary then to calculate glycogen for the moisture and ash-free constituents of the entire shell contents of the specimens used. Glycogen estimations were made by the well-known Pfluger method. Ash determinations were difficult to make because of the slowness with which some of the organic matter burned and the tendency of some of the inorganic matter to volatilize. The use of porcelain crucibles kept at low red heat during about two hours in a muffle furnace was found to be satisfactory.

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[a] The experimental manipulation, aside from chemical analysis, in some of these experiments was conducted by Dr. G. H. Robinson and in others by Dr. W. W. Browne. Three of the chemical analyses were made by Dr. G. H. White.

SEASONAL VARIATIONS IN GLYCOGEN CONTENT OF OYSTERS.

The results indicate a seasonal variation in the glycogen content of oysters. In the specimens observed it was very low during the early summer. This may have been due to spawning or to the fact that the oysters used early in July had been recently transplanted to shallow water, where they would be exposed at very low tides. At any rate the figures show that glycogen may become greatly depleted. It steadily increases, however, during the summer and fall, until just before cold weather it amounts to 20 per cent or more of the dried weight. Lower figures were obtained in the winter. Some analyses to indicate these changes are grouped in Table 1.

TABLE 1.—SEASONAL VARIATION IN GLYCOGEN CONTENT OF OYSTERS.

Source of oysters.	Date.	Oysters used.	Average weight.	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
			Grams.	*Per cent.*	*Per cent.*	*Per cent.*
Wareham, Mass.	July 11	20	88	36.45	2.77	4.37
Do.	July 31	14	72	25.30	9.47	12.70
Cotuit, Mass.	July 29	12	89	23.60	10.35	13.57
Wareham, Mass.	Aug. 6	19	72	30.87	9.69	14.02
Do.	Aug. 27	18	55	25.72	11.80	17.38
Narragansett Bay	Nov. 14	15	92	19.05	21.50	26.55
Do.	Feb. 3	14	83	22.17	15.52	19.94

These observations were not primarily undertaken for the purpose of studying seasonal variations in the glycogen content of oysters under natural conditions. A large number of determinations on specimens taken directly from the oyster beds are not, therefore, at hand. Those given in Table 1, in fact, are mostly analyses made for comparison with determinations on experimental oysters. Altogether, however, they constitute a sufficiently striking and regular series to be worthy of note and agree with the observations of Milroy.[a] That glycogen would be used up during warm weather might be expected from the author's experiments on the oxygen requirements of oysters,[b] which showed the direct relationship between temperature and oxidation. It is well known that increased oxidation in animals involves the utilization of some of the stored-up glycogen.[c] Further observations on the glycogen variations during winter months would furnish chemical evidence as to whether oysters hibernate or continue to feed during the cold weather. These data, so far as they go, favor the hibernation idea.

THE FORMATION OF GLYCOGEN FROM DEXTROSE.

The formation of glycogen from dextrose was tested out by putting oysters into large, shallow glass dishes containing sea water of known specific gravity and known amounts (usually 0.25 per cent) of either pure dextrose or crude glucose. It was found that larger amounts of sugar were toxic. Experiments employing 1 per cent and even some with 0.5 per cent of dextrose had to be discarded because of high mortality among the oysters. The toxicity of an unphysiological abundance of dextrose is in accord with common observations on higher animals. Oxygen was constantly furnished throughout the experiment by bubbling air from an aspirator bottle through glass tubes reaching to the bottom of the dish. At the end of a period, varying from two to five days, the entire shell contents of the oyster were dried down and analyzed. Analyses, for comparison and control, were made on oysters taken from the same source as those used for feeding with sugar, but analyzed at the beginning of the experiment; and also analyses of oysters from the same lot kept meanwhile in aerated sea water containing no sugar. In one experiment a further control consisted in the analyses of oysters having the same origin as the others, but kept during the time of the experiment in a wire cage suspended in the water near the Government docks at Woods Hole Harbor. Here with garbage and animal and plant life in very great abundance, feeding conditions were about as rich as could be obtained. The results of the experiments are shown in Table 2.

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[a] Milroy: Seasonal variation in the quantity of glycogen present in samples of oysters. Department of Agriculture and Technical Instruction for Ireland. Fisheries Branch. Scientific Investigation, 1907. No. IV.

[b] Mitchell: Oxygen requirements of shellfish. Bulletin United States Bureau of Fisheries, vol. XXXII, 1912, p. 209.

[c] Lusk: Elements of the science of nutrition. 1909.

TABLE 2.—FORMATION OF GLYCOGEN FROM DEXTROSE.

Experiment No.[a]	Oysters used.	Average weight of oyster.	Treatment of oysters.	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
			GROUP I.			
		Grams.		*Per cent.*	*Per cent.*	*Per cent.*
1	20	88	Analyzed at beginning of experiment to be compared with treated oysters of Nos. 2, 3, and 4	36.45	2.77	4.37
2	17	80	In sea water, sp. gr. 1.023, containing ¼ per cent of dextrose during 48 hours	33.70	4.11	6.20
3	15	59	In sea water, sp. gr. 1.015, containing ¼ per cent of dextrose during 48 hours	29.45	4.38	6.21
4	15	66	In running sea water in aquarium for 15 days, then treated exactly like No. 3	23.68	8.55	11.21
			GROUP II.			
5	14	72	Analyzed as soon as brought from beds, to be compared with Nos. 6, 7, 8, and 9	25.30	9.47	12.70
6	20	73	In sea water, sp. gr. 1.015, containing ¼ per cent dextrose during 48 hours	21.65	11.30	14.43
7	20	70	In sea water, sp. gr. 1.015, with no dextrose, treated like No. 6 during 60 hours	24.35	9.43	12.47
8	19	71	Taken from running sea water in aquarium at time No. 6 ended. Control of Nos. 6 and 7	30.08	8.63	12.36
9	19	72	Kept in wire cage in Woods Hole Harbor during 50 hours before analysis	30.87	9.69	14.02
			GROUP III.			
10	20	58	Analyzed as soon as brought from beds, to be compared with Nos. 11, 12, and 13	25.57	9.28	12.47
11	20	62	In sea water, sp. gr. 1.015, containing ¼ per cent crude glucose during 48 hours	14.86	12.08	14.19
12	19	55	In running sea water in aquarium 48 hours, then treated with glucose like No. 11, 72 hours	19.00	12.75	15.74
13	20	55	In sea water, sp. gr. 1.015, without sugar during 76 hours. Had been in aquarium 48 hours. Control for No. 12	23.12	10.05	13.07
			GROUP IV.			
14	15	92	Analyzed as soon as brought from beds, to be compared with Nos. 15 and 16	19.05	21.50	26.55
15	15	92	In sea water, sp. gr. 1.022, containing ¼ per cent dextrose during 65 hours	18.33	22.77	27.90
16	15	92	In sea water, sp. gr. 1.022, without dextrose during 67 hours	19.99	21.26	26.33

[a] All oysters used in experiments of the several groups came from the same beds at the same time.

These results show clearly that glycogen may be formed in the oyster from dextrose, while experiment No. 9 shows that even richest feeding in excellent normal conditions with abundant tide flow did not cause as much glycogen formation as that obtained by treatment during the same time with a 0.25 per cent dextrose solution and under somewhat adverse conditions at that. The oysters were crowded into a dish in water that was not changed throughout the time of the experiment. Indeed, experiments Nos. 7 and 8, compared with No. 5, show how adverse conditions in the laboratory may tend to lower the glycogen content. The great variations in ash percentages are due not only to the differences in density of water, but also to variations in the amount of sea water included in the shell contents used for analysis. The metabolic changes in glycogen, therefore, are more fairly represented by the percentages in the ash-free solids than by those in the total solids of the oyster. It apparently makes no difference whether the oysters at the start contain much or little glycogen. The amount formed in any case is about the same for two or three days' treatment with dextrose, i. e., 1.5 to 2.5 grams of glycogen to every 100 grams of organic matter. The numbers of oysters used in these experiments would seem to exclude the possibility of accounting for variations by mere individual differences, especially since the dried shell contents of all oysters used in any one experiment were very thoroughly ground and mixed before analysis.

The storage of glycogen can not continue indefinitely under the adverse conditions used in these experiments. In one case oysters kept in aerated but unchanged sea water, containing 0.25 per cent of dextrose, during five days, yielded glycogen to the amount of 11.12 per cent of the ash-free solids, but the corresponding figure for some of the same oysters analyzed at the beginning of the experiment was 13.57 per cent.

Further experiments to test this point were made as shown in Table 3.

TABLE 3.—EFFECT OF VARYING DURATIONS OF DEXTROSE FEEDING ON GLYCOGEN FORMATION.

Experiment No.	Duration of treatment.	Treatment of oysters (15 used for each analysis).	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
	Days.		*Per cent.*	*Per cent.*	*Per cent.*
25	1	In aerated sea water containing ¼ per cent dextrose during 20 hours	32.17	6.07	8.94
26	2	Same as No. 25 but continued during 44 hours	31.12	5.16	7.49
27	3	Same as Nos. 25 and 26 but continued during 68 hours	30.35	4.34	6.23
28		From same lot as Nos. 25, 26, and 27, analyzed as a control	34.40	4.84	7.39
29		Analyzed at beginning of experiments Nos. 30 to 34 as a control	25.56	3.74	5.01
30	1	In aerated sea water containing ¼ per cent dextrose, 1 day	33.46	5.06	7.60
31	2	Same as No. 30, 2 days, water (¼ per cent dextrose) renewed second day	31.22	6.11	8.87
32	3	Same as Nos. 30 and 31, 3 days, water (¼ per cent dextrose) renewed daily	29.85	4.68	6.68
33	4	Same as No. 32, 4 days	30.60	5.03	7.25
34	5	Same as No. 33, 5 days	29.50	4.89	6.97
35		From same lot as Nos. 29 to 34 analyzed at end of No. 34 as control	34.70	3.96	6.06

These experiments show that the maximum glycogen formation under these circumstances occurs in about two days. Although in experiments Nos. 30 to 34 the water containing dextrose was daily renewed and constantly aerated, yet glycogen did not show a progressive daily increase. The control oysters (experiment No. 29) were analyzed immediately after they were brought from the beds at Wareham, Mass. There the specific gravity of the water is lower than at Woods Hole. This explains why the second set of control oysters (experiment No. 35), analyzed after remaining five days in Woods Hole water, gave a higher ash yield than the first lot (experiment No. 29), though taken from the same beds at the same time. What effect this may have had on glycogen formation is discussed later. That the oysters of experiments No. 31 to 34 did not have as high an ash content as those of No. 35 may indicate a failure to remain open and feed continuously under the experimental conditions. With smaller concentration (0.1 per cent) of dextrose, glycogen formation may continue for three days. (See experiments Nos. 37 and 38, Table 4.)

The optimum concentration of dextrose for glycogen formation was found to be about 0.25 per cent. It was found that 1 per cent of dextrose was toxic. Oysters exposed to it showed inability to close their shells normally after 24 hours' exposure and rapidly died off in about two or three days. If removed from the sugar-containing water soon after signs of distress appeared, the oysters recovered their normal behavior in the course of a few days' immersion in running sea water. Some experiments contrasting the glycogen formation in 0.25 per cent dextrose with that in 0.1 per cent dextrose are given in Table 4.

TABLE 4.—THE EFFECT OF DIFFERENT CONCENTRATIONS OF DEXTROSE ON GLYCOGEN FORMATION.

Experiment No.	Concentration of dextrose.	Treatment of oysters (15 used for each analysis).	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*
36	0.1	Control analysis to be compared with Nos. 37 and 38	35.50	5.48	8.49
37	.1	In sea water, sp. gr. 1.015, with 0.1 per cent dextrose, 36 hours, aerated	30.72	6.34	9.15
38	.1	Same as No. 37, but continued for 72 hours	28.65	7.44	10.45
39	....	Control analysis to be compared with Nos. 43 and 44	31.92	7.79	11.50
43	.1	In sea water, sp. gr. 1.022, with 0.1 per cent dextrose, 24 hours, aerated	32.95	9.90	14.76
44	.25	Same as No. 43, but with 0.25 per cent dextrose	31.50	12.70	18.53
45	....	Same as Nos. 43 and 44, but without dextrose	32.90	8.98	13.38

By comparison of experiments Nos. 37 and 38 with 6, 11, and 12 (shown in Table 2), evidence of more rapid formation of glycogen in 0.25 per cent dextrose than in 0.1 per cent is seen in addition to the data shown in Table 4.

The effect of different specific gravities of the sea water containing dextrose on glycogen formation was studied. Fresh or nearly fresh water did not permit glycogen formation. The evidence points to the fact that any change in the salt concentration at the time oysters are transferred from ordinary sea water to dextrose-containing water is a deterrent to maximum glycogen formation. Experiments bearing on this point are reported in Table 5.

TABLE 5.—THE EFFECT OF VARYING SPECIFIC GRAVITY OF THE SEA WATER ON GLYCOGEN FORMATION.

Experiment No.	Specific gravity of the water.	Treatment of oysters (15 used for each analysis).	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
			Per cent.	*Per cent.*	*Per cent.*
39	1.023	Control analysis to be compared with Nos. 40 to 45	31.92	7.79	11.50
40	1.000	In aerated fresh water containing 0.1 per cent dextrose, 24 hours	27.55	8.75	12.08
41	1.010	In aerated water (½ fresh, ½ sea water) with 0.1 per cent dextrose, 24 hours.	22.00	10.79	13.84
42	1.016	In aerated water (¼ fresh, ¾ sea water) with 0.1 per cent dextrose, 24 hours.	27.75	10.57	14.64
43	1.023	In aerated sea water with 0.1 per cent dextrose, 24 hours	32.95	9.90	14.76
44	1.023	In aerated sea water with 0.25 per cent dextrose, 24 hours	31.50	12.70	18.53
45	1.023	Same as Nos. 43 and 44, but without dextrose, control	32.90	8.98	13.38
46	1.023	Control analysis to be compared with Nos. 47 to 49	34.20	4.20	6.39
47	1.000	In aerated fresh water with 0.25 per cent dextrose, 24 hours	31.62	3.82	5.60
48	1.000	Same as No. 47, but continued 72 hours, water changed daily	24.84	4.02	5.36
49	1.023	Control analysis, same lot as Nos. 46 to 48, in sea water until end of experiment No. 48	37.60	3.51	5.64
50	1.023	Control analysis to be compared with Nos. 51 and 52	35.75	4.54	7.08
51	1.006	In aerated water (¼ sea water, ¾ fresh) with 0.1 per cent dextrose, 36 hours.	26.35	5.36	7.28
52	1.006	Same as No. 51, but continued 72 hours	19.90	5.41	6.75
53	1.023	Control analysis to be compared with Nos, 54 and 55	37.48	3.69	5.90
54	1.010	In aerated water (½ fresh, ½ sea water) with 0.1 per cent dextrose 72 hours.	23.55	4.45	5.82
55	1.023	Control analysis, same lot as Nos. 53 to 54, in sea water until end of experiment No. 54	36.73	4.12	6.50

It is seen from Table 5 that the greatest glycogen formation from dextrose occurred in experiment No. 44. Over 60 per cent increase occurred in 24 hours. Sea water from the harbor where the oysters had been kept previous to the experiment was used, so that during the sugar feeding (0.25 per cent dextrose in the water) the oysters experienced no considerable change in the density of the medium. With lower densities some glycogen formation appeared to occur in experiments Nos. 40, 41, and 42; but the results of experimets Nos. 40 and 41 when compared with the control, experiment No. 45, are not significant increments. This series of experiments (Nos. 39 to 45) was done early in September when glycogen formation in oysters is at its height under natural conditions, so that the oysters kept in a small amount of aerated but unchanged sugar-free sea water were able to show a significant increase in glycogen during 24 hours. Water of specific gravity of 1.015 to 1.016 does not so completely inhibit glycogen formation in oysters that have previously been in water of specific gravity of 1.022 to 1.023. Examination of the results of experiments reported in Table 2 yields additional evidence on this point. An increase in the specific gravity of the sugar-containing medium may also, within certain limits, allow considerable glycogen formation. This is shown by a comparison of the results of experiments Nos. 29, 30, 31, and 35 as reported in Table 3.

An attempt to study the effect of the varying concentrations of specific inorganic salts was made. The immediate object was to find the effect on glycogen storage of adding phosphates to sugar-containing water whose density was low enough to check the glycogen process. The experiments as reported in Table 6 show a tendency of phosphates to interfere with glycogen storage. The experiments, Nos. 61, 62, and 63, in which phosphates were added, all resulted in a lowered glycogen content of the oysters although sugar was plentifully furnished.

TABLE 6.—THE EFFECT OF PHOSPHATES ON GLYCOGEN FORMATION FROM SUGAR IN DILUTED SEA WATER.

Experiment No.	Treatment of oysters (15 used for each analysis).	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
	In experiments Nos. 61 to 65 a mixture of equal parts of sea and fresh water (sp. gr. 1.010) was used.	*Per cent.*	*Per cent.*	*Per cent.*
60	Control analysis to be compared with Nos. 61 to 65	29.27	10.53	14.90
61	In aerated, diluted sea water, with 0.15 per cent disodium phosphate and 0.25 per cent dextrose, 24 hours	21.37	9.25	11.77
62	In aerated, diluted sea water, with 0.5 per cent disodium phosphate and 0.25 per cent dextrose, 24 hours	24.07	7.32	9.65
63	In aerated, diluted sea water, with 0.5 per cent disodium phosphate, 0.25 per cent dextrose, and 0.25 per cent calcium chloride, 24 hours	19.77	10.76	13.40
64	In aerated, diluted sea water, with 0.25 per cent dextrose, 24 hours	21.21	12.50	15.88
65	In aerated, diluted sea water, without addition of salt or sugar, 24 hours, as a control to Nos. 61, 62, 63, and 64	23.30	10.67	13.91

The possibility of the formation of glycogen from dextrose by oyster meats separated from the shells was tested, because in the present-day practice of the oyster industry the meats, before packed for shipment, are washed freely with tap water during periods varying in different establishments from a few minutes to several hours. If the glycogen increment, then, could be obtained during this process by addition of glucose to the wash water, an obvious economy would be attained. Only one such experiment is reported, as time and opportunity for conducting others have not yet been found. The result of this, shown in Table 7, was entirely negative. This might be expected physiologically. With the circulation destroyed, death coming on in the tissues, and metabolism coming to a stop, it is hardly likely that a synthetic process like glycogen formation would occur with sufficient activity to overbalance the hydrolytic process of glycogenolysis known to occur in various dying animal tissues.

Table 7.—Treatment of Shelled Oysters with Dextrose.

Experiment No.	Oysters used.	Total weight of oysters.	Treatment of oysters.	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
		Grams.		*Per cent.*	*Per cent.*	*Per cent.*
21	14	125	Opened at packing house of Narragansett Bay Oyster Co. (analyzed at once)	11.22	21.58	24.31
22	14	125	In tap water containing 0.5 per cent of dextrose during 22 hours	8.42	22.22	24.26
23	14		In tap water containing no dextrose during 22 hours	7.90	22.85	24.80

THE FORMATION OF FAT FROM CARBOHYDRATE NUTRIMENT.

The formation of fat from carbohydrate nutriment was also observed in oysters, though experiments on this point were not as numerous as on glycogen formation. Results are shown in Table 8.

Table 8.—Formation of Fat from Dextrose.[a]

Experiment No.	Treatment of oysters.	Fat in dried meats.	Fat in ash-free solids.
		Per cent.	*Per cent.*
[b] 8	In Woods Hole Harbor 50 hours before analysis	2.55	3.25
[b] 6	In sea water containing ¼ per cent dextrose, 48 hours	3.13	3.98
[c] 10	Analyzed as soon as brought from beds	3.41	4.58
[c] 11	In sea water containing ¼ per cent glucose, 48 hours	6.36	7.47

[a] Further data on these analyses are contained in Table 2.
[b] Oysters used in experiments Nos. 6 and 8 were from the same lot.
[c] Oysters used in experiments Nos. 10 and 11 were from the same lot.

LACK OF GLYCOGEN FORMATION FROM DEXTRIN.

The failure of oysters to form glycogen from dextrin was observed in two experiments. This possibility was tested because only crude commercial glucose, which always contains dextrin, could be used economically in practical work with oysters. Kahlbaum's purified dextrin was used. Results are shown in Table 9.

Table 9.—Lack of Glycogen Formation from Dextrin.

Experiment No.	Oysters used.	Average weight of oysters.	Treatment of oysters.	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
		Grams.		*Per cent.*	*Per cent.*	*Per cent.*
17	14	84.9	In sea water, sp. gr. 1.022, with no dextrin. Treated like No. 18 during 60 hours	21.55	17.22	22.01
18	14	82.8	In sea water, sp. gr. 1.022, containing 0.5 per cent dextrin, during 60 hours	21.00	16.86	21.34
19	14	83.5	Analyzed as soon as brought from beds	22.17	15.52	19.90
20	14	83.4	In sea water, sp. gr. 1.022, containing ¼ per cent dextrin, during 60 hours	23.04	14.80	19.23

NUTRITION BY SEAWEEDS AND PROTOZOA.

The nutrition of oysters by fragments of seaweed was also studied. This idea seems to have been little considered because of the generally prevailing view that algæ and other microscopic life constitute the food of oysters.[a] In these experiments oysters were fed in glass jars of aerated water with sea lettuce (*Ulva lactuca*) chopped into fine fragments and added fresh at intervals of one or two days. It was found that the material had to be in fresh condition, because if it darkened and decomposed, or if the water in the containers was not changed frequently enough, the oysters would die. That this material was ingested was shown by repeated microscopic observations of the stomach contents of oysters so fed. All the sea water used was carefully filtered through several thicknesses of fine filter paper so that, as shown by subsequent microscopic examination, it was freed from algæ. It is true that some algæ clung to the sea lettuce, and Protozoa and bacteria from the same source were also present in the preparation. The multiplication of these organisms provided, therefore, a part of the nutrition for the oysters. Several experiments were started, but only one was successfully continued long enough to be of value. The result is shown in Table 6. It indicates that the seaweed fragments contributed to the nourishment of the oyster.

Whether accumulations of seaweed on oyster beds may cause the death of oysters is a question of practical interest to oystermen. Gorham[b] observed the death of oysters on beds where seaweeds in which *Ulva* predominated had lodged in masses sufficient to cause putrefaction. In his opinion the seaweed was the cause of death.

The following experiments on this point were undertaken: Wooden boxes about 30 inches square and 3 inches deep were filled with sand and gravel, and 25 oysters were laid on top of the gravel in each box. A basket of galvanized wire netting was made so as to fit over the top of each box with a space of 3 or 4 inches above the oysters. Two such boxes, one with the wire basket loosely filled with seaweeds and the other without them, were then anchored together in each of several locations on the shores of Narragansett Bay in waters suitable for oyster culture. The seaweeds used were mostly *Ulva* with some eelgrass. In one case *Ulva* alone was used. Four such experiments were carried out. In two of them the oysters were taken up for observation after 29 days, in one after 25 days, and in one after 14 days. In every case the oysters under seaweeds were found to be dead and badly decomposed, with the meats running out of the shell. Of the 100 oysters so treated only 7 were found alive and 6 of these had discolored meats showing signs of incipient putrefaction. All the control oysters showed no pathological conditions or signs of decay, and from the new shell formation during the progress of the experiment, showed abundant evidence of flourishing growth. It would seem, then, that although seaweed may serve as food for oysters, accumulations of it in places where the tide does not keep it sufficiently in motion must be guarded against in oyster culture.

The nutrition of oysters by Protozoa was also investigated. Rich cultures of various Protozoa were added daily to a dish of filtered, aerated sea water containing oysters. As algæ were excluded from this experiment, only Protozoa and bacteria, but with Protozoa predominating, served as food for the oysters. They appeared after 17 days, when the experiment was ended, to be in a nutritive condition comparable to the oysters from the same source examined before the experiment. The result of chemical analysis is shown in Table 10.

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[a] Brooks, William K.: The Oyster. 225 p., 1905. Baltimore.

[b] Gorham: Annual Report, Rhode Island Shellfish Commission, 1914.

TABLE 10.—THE NUTRITION OF OYSTERS BY SEAWEED AND PROTOZOA.[a]

Treatment of oysters.	Ash in dried meats.	Glycogen in dried meats.	Glycogen in ash-free solids.
	Per cent.	*Per cent.*	*Per cent.*
Analyzed as soon as brought from beds. (See experiment 1, Table 2)	36.45	2.77	4.37
Fed with *Ulva lactuca* during 14 days	32.56	7.03	10.43
Fed with Protozoa cultures during 17 days	36.70	4.55	7.18

[a] The oysters used in these experiments were from the same lot.

An attempt was made to follow the nutritive condition of the experimental oyster by determinations of nitrogen in the dried tissues. From the results of 20 analyses no definite conclusions could be drawn. In the various artificial feedings, changes in the nitrogen content of the tissues were observed, but they were always small and in most cases merely percentage changes attributable to the altered proportions of salts and glycogen, rather than to a change in the actual amount of protein present.

SUMMARY.

A summary of the results of this work follows:

1. Evidence was obtained of a seasonal variation in the glycogen content of oysters. A depletion occurs in the warm weather but is followed by a storing-up process in the latter part of the summer and in the fall. Glycogen seems to decrease during the coldest weather. This favors the idea of hibernation. The results on seasonal variation agree with the results of Milroy.
2. Glycogen may be formed in the oysters from dextrose. Fat storage may occur simultaneously.
3. The optimum conditions for this process are: (*a*) Duration of dextrose feeding two to three days; (*b*) concentration of dextrose equal to about 0.25 per cent; and (*c*) water density not greatly different from that in which the oysters have previously been.
4. Excess of sodium phosphate in the medium may check glycogen formation from sugar.
5. Formation of glycogen from dextrin was not obtained.
6. Failure of glycogen formation from sugar by oysters taken from the shells was observed.
7. Evidence that Protozoa and fragments of seaweed (*Ulva lactuca*) may serve as food for oysters is given.
8. Decaying seaweeds lodged above oysters that are under otherwise good growing conditions may cause their death.

THE ECONOMIC RELATIONS, ANATOMY, AND LIFE HISTORY OF THE GENUS LERNAEA

❧

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Contribution from the United States Fisheries Biological Station, Fairport, Iowa

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INTRODUCTORY.

During the summer of 1914 while working at the Bureau of Fisheries station at Fairport, Iowa, many new species of copepods parasitic upon fresh-water fish were obtained, and interesting bionomic relations between these parasites and mussel glochidia were discovered. The results of these investigations have already been published.[a]

Among the new species was one belonging to the genus *Lernæa*, which proved to be of exceptional interest, since larvæ were found in various stages of development. But not enough were obtained to give anything like a complete life history, and consequently this was left until the following summer, 1915. At that time additional larval stages were found and the entire development was carried up to the adult form.

Two new species were discovered and those already described were carefully reviewed, so that the entire genus might be placed upon a sound and substantial basis. Specimens of the adults of various species were sectioned and the entire internal anatomy was reconsidered, together with the oogenesis, in the light of the series thus obtained. And it is vastly to the credit of those old observers that all the wonderful advance in technique since their day has only been able to supplement, and not to supplant, their painstaking work. The larvæ were also sectioned and their anatomy was fully worked out.

Material was thus provided for both the external and internal morphology of the larva as well as the adult, for much of the histology, and for the entire life history, all of which have been incorporated in the present paper.

This work, especially the life history, is one of the most important factors in determining the systematic position of the genus, which ought now to be fairly well established.

With the two new species here presented the number now recognized in the genus reaches 17, more than half of which are American.

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[a] Bulletin, Bureau of Fisheries, vol. 34, 1914, p. 331–374, pl. 60–74.

HISTORICAL.

The genus *Lernæa* was founded by Linnæus in 1758, in the tenth edition of his "Systema Naturæ," with the three species, *cyprinacea*, *asellina*, and *salmonea* (p. 655).

The species *asellina*, a salt-water form, has since become the type of the genus *Medesicaste*, while the species *salmonea*, a fresh-water form, is the type of the genus *Salmincola*. The species *cyprinacea*, another fresh-water form, thus becomes the type of the original genus by elimination as well as by priority.

In 1822[a] Blainville founded his new genus *Lernæocera*, and gave as his first or type species *branchialis*, which had been included by Linnæus in his genus *Lernæa* in the twelfth edition of the "Systema Naturæ." Blainville also included in his new genus a second species, *cyclopterina*, which later became the type of the genus *Hæmobaphes*. His third species was new to science and he named it *surriraiis* for Dr. Surriray of Havre, who sent him a specimen. But his description gave the egg strings as uniseriate, which would exclude it from the genus, and in all probability it was identical with *Lernæenicus sprattæ*. Of course Blainville had no right to add, as his fourth and last species, *cyprinacea*, the type of Linnæus' genus *Lernæa*.

We thus have the genus *Lernæa* established by Linnæus in 1758, with *cyprinacea* as a type and including the species *branchialis* (1767), and the genus *Lernæocera* established by Blainville in 1822, with *branchialis* as a type and including the species *cyprinacea*.

Curiously enough, in endeavoring to straighten this muddle, subsequent authors have reversed the genera, and *branchialis* has come to be accepted as the type of the genus *Lernæa*, while *cyprinacea* was formally declared to be the type of *Lernæocera* by Cunnington in 1914.[b]

But *Lernæa* is the oldest genus amongst the parasitic copepods, and its ancient prestige must be restored by giving it again its original type species and making it a fresh-water instead of a salt-water genus.

In 1832[c] Nordmann published a more complete description of *L. cyprinacea*, but failed as Blainville had done to find the swimming legs.

His paper was of great value, however, because it contained the description and figures of a newly hatched nauplius larva, the first and the best that have ever been published.

In 1833[d] Burmeister presented a second description of *L. cyprinacea*, illustrated by good figures; he also showed that the species described by Nordmann was not *cyprinacea* at all, but a species new to science, which he named *esocina* from its host. But he regarded the two pairs of antennæ as the anterior and posterior rami of a single appendage, and he added one more to the list of those who had failed to find the swimming legs. The swimming legs were first discovered by Brühl in 1860 on a species which he named *Lernæocera gasterostei*, but which was evidently the same as the one described by Nordmann, viz, *esocina*.

In the following year Claus confirmed Brühl's discovery upon two specimens sent him by Prof. Leuckart and called by the latter *Lernæa gobina*, but which Claus after examination believed to be identical with Brühl's species. In addition he corrected a mistake common to all previous investigators, by whom the two pairs of antennæ had been transposed, the anterior pair having been called posterior and the posterior pair anterior. Again, in 1867,[a] he published a description of *Lernæocera esocina*, in which he mentioned both *gobina* and *gasterostei* as distinct species, and added many details of external and internal structure. In 1863 Krøyer added three new species, *catostomi*, *pomotidis*, and *phoxinacea*, to the genus, the first two of which were from the Mississippi River. In 1865 Heller added another species, *lagenula*, obtained during the voyage of the *Novara*.

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[a] Jour. Physique, vol. 95, p. 372–380, 437–447.

[b] Proc. Zool. Soc. London, 1914, p. 819–829.

[c] Mikrogr. Beiträge, pt. 2, p. 123.

[d] Acta Acad. Caes. Leop. Carol. Nat. Cur., vol. 17, p. 309.

In 1870[b] Hartmann published the description of a species which he named *barnimii*, together with excellent figures which included the eggs and the development up to the metanauplius stage. This is by far the best paper upon any species of the genus, and it included as much of the internal structure as could be made out without sectioning.

Meanwhile here in the United States Le Sueur had established in 1824[c] the first American species, *cruciata*, upon material obtained in Lake Erie. After a long interval he was followed by Kellicott with two other American species, one, *tortua*, from New York State in 1881,[d] and the other, *pectoralis*, from Michigan in 1882.[e]

With these 10 species the genus remained until 1914,[f] when Cunnington published a short paper including a "List of described species" and three from the Tanganyika region in Africa that were new to science.

In spite of its brevity and omissions this paper proved to be of considerable value because it summed up all the described species and presented a key for their identification. Among other things, with reference to the genus, Cunnington stated, "A careful study of these forms has given me the impression that two or three of them may merit separation as distinct genera" (p. 822), but he wisely concluded not to do this at present. On the next page he said: "The appendages appear to show comparatively minor differences within the limits of this genus, and have not been appealed to for the purpose of establishing new species."

The appendages certainly are remarkably similar in all the species examined by the author, but this very fact precludes the establishment of new genera, for which there must be characteristic differences in the appendages as well as in body form.

Cunnington mentioned Krøyer's *catostomi* and *pomotidis*, Heller's *lagenula*, and his own *diceracephala* as possible candidates for the prospective new genera.

The first three are shown to be good Lernæans in this paper. With reference to Cunnington's species the chief distinctive feature mentioned is "the existence of only two cephalic horns—apparently the dorsal pair—instead of four." But it may be noted that the ventral pair in another of his species, *temnocephala*, are hardly large enough to be called horns rather than spines, the ventral pair in *variabilis* and *tenuis* are also often very minute, and in *anomala* they have entirely disappeared.

These species certainly belong to the present genus in spite of considerable variation in the number and structure of the horns, and the same is probably true of *diceracephala*. Unless in addition to the lack of ventral horns or the presence of a dorsal horn there were also well-marked differences in the appendages, it would be manifestly inadvisable to establish any new genus.

ECOLOGY.

The parasites belonging to this genus are immovably anchored in the tissues of the host's body. Consequently we should expect to find, as in the Lernæopodidæ, considerable sexual dimorphism, a loss of the powers of locomotion, and modified means of prehension. But the peculiar life history greatly modifies these characters and even does away with some of them.

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[a] Sitzungsb. Gesellsch. Beförd. ges. Naturw. Marburg, p. 5–12.

[b] Arch. Anat. Physiol., p. 726–752.

[c] Jour. Acad. Nat. Sci. Phila., vol. 3, p. 286.

[d] Proc. Amer. Soc. Micros., vol. 2, p. 41.

[e] Loc. cit., vol. 4, p. 75.

[f] Proc. Zool. Soc. London, 1914, p. 819–829.

Sexual dimorphism.—Since the females attain a length in some species of more than 20 mm. we would naturally look for a much smaller male, with marked differences between the sexes. But a study of the development convinces us that there is no sexual dimorphism for the following reasons: There is no disparity in size up to the close of the copepodid stages, at which time both sexes become mature and their union takes place. After this union the male either dies at once or becomes a free swimmer for a short time and then dies. And while the female subsequently seeks out a final host and undergoes upon it marvelous changes in size and form, we can not in fairness compare her altered proportions with those of the male before his death, and hence there is no real dimorphism.

Locomotion.—The adults are incapable of locomotion, but the nauplius, metanauplius, and copepodid larvæ are exceedingly active and move about constantly and vigorously. When placed in a watch crystal of water the copepodid larvæ swim around in search of something to which they can cling.

If there is a fragment of a gill filament present they all congregate upon it and remain there. Every now and then they leave in search of a better location, but finding none return to the filament.

If there is nothing present to which they can fasten they swim about until tired, then come to rest upon their backs on the bottom of the watch glass, and may remain there an hour or more. They can be kept alive in this way for several days. When swimming or when moving about over the gills the motion of the larva is jerky and spasmodic. They swim with the back downward, darting for a short distance in almost any direction, sometimes in a straight line, sometimes in a wide curve, stopping wherever it happens, usually in a horizontal position, and then sinking slowly to the bottom.

But they also have the ability, possessed by many of the free swimmers, of holding themselves suspended from the surface film of the water by means of their antennæ, their bodies hanging in a vertical position, and they often come to rest in this manner and remain for some minutes.

On the gills of the fish they always move about with their ventral surface next to the filament, using the swimming legs for locomotion and the second antennæ and maxillipeds for prehension. They catch hold of the filament and kick themselves free with a jerk that helps to send them forward. When resting the first antennæ are extended horizontally, the two being in the same straight line, while the second pair are turned ventrally and parallel to each other. The maxillipeds also stand out ventrally at right angles to the surface of the head, ready for use. During locomotion the posterior half of the body is often inclined ventrally, the flexure occurring between the fourth and fifth-sixth (fused) thorax segments. After the short rest at the surface or the long rest on the bottom the larva moves about as actively as ever, and this alternate motion and resting is kept up until a host is found.

Prehension.—The organs of prehension are the second antennæ and the maxillipeds; these are similar in both sexes and are the only means of prehension possessed by the male. The larvæ never develop a frontal filament like that of the Lernæopodidæ and the other Lernæidæ, but continue to move about freely during their entire larval life.

But the female, after she has sought out her final host and fastened herself to it by means of the second antennæ and maxillipeds, develops an entirely different method of attachment. She first burrows through the skin of the host and into the underlying tissues by means of her second antennæ, her powerful maxillæ, and her maxillipeds, until the anterior half of the body is entirely buried. The segments of the thorax then begin their final lengthening and transformation, and at the same time processes or horns, two, three, or four in number, grow out laterally from the cephalothorax into the surrounding tissue and anchor the head securely in place. Once formed, the function of prehension is entirely assumed by these horns for the remainder of the creature's life. The only subsequent use for the second antennæ and maxillipeds is to pull the mouth into contact with the food; for this purpose they retain to the full their form and powerful musculature.

Specimens of *variabilis* have been found which did not burrow through the skin, but were fastened to one of the fish's scales. In such instances the horns are still developed, but instead of penetrating the tissues they are flattened out upon the scale and more or less fused with it. Here also, therefore, the horns assume the function of attachment to the host, but there is more work left for the second antennæ and maxillipeds in the procuring of food.

As a result of the burrowing usually practiced by the larva we find that the tissues of the host are profoundly modified; those in immediate contact with the head and neck of the parasite harden into a tough, leathery skin which helps to hold the creature in place, and which is usually found enveloping the head and anterior end of the parasite after it is removed from its host. There is often also a swelling of the surrounding tissues, so that a good-sized lump or tumor is formed, perforated through the center and with the posterior part of the parasite projecting from the perforation. Sometimes the head and neck of the parasite work about so much within the burrow that it keeps the flesh of the host raw and bleeding, similar to the sores on the sunfish (*Mola mola*) occasioned by various species of the Caligidæ. Le Sueur and Kellicott mentioned such sores in connection with the species obtained by them.

Location.—The larvæ are always found upon the gills, either clinging to the filaments or to the skin covering the arches. After mating when the female copepodid larva seeks out her final host she fastens to the outside of the body instead of the gills, in the place where she is to be transformed into an adult. Mating and the attachment of the spermatophores has entirely changed her choice of a location and she now seems to prefer the vicinity of one of the fins, usually the dorsal.

And when six or eight specimens are found upon the same fish they are arranged in a row alongside this same dorsal fin. But they never burrow through the flesh into the body cavity, and hence do not, like some of the other Lernæidæ, attack the heart, the liver, or any other vital organ.

Relation to mussel glochidia.—It has been found by the author that there is a well-defined antagonism between mussel glochidia and parasitic copepods belonging to the Ergasilidæ.[a]

The same antagonism evidently exists between the glochidia and the copepodid larvæ of the present genus.

During the summer about 150 short-nosed gars (*Lepisosteus platostomus*) were examined for these larvæ. These fish were obtained in "Patterson Lake," "Drury Lake," and similar slews, which the fishing crew visited regularly and the fish of which they infected artificially with mussel glochidia. Gars were often obtained in the seine along with other fish and were infected the same as the rest. Of the 150 specimens examined 53 had been thus artificially infected with glochidia, a trifle more than a third of the whole, and upon these not a single copepodid larva was found.

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[a] Bulletin, United States Bureau of Fisheries, vol 34, 1914, p. 345.

In many instances both infected and uninfected gills were removed and placed together in a jar of water over night. The gills that had no glochidia were well covered with copepodid larvæ and many specimens were obtained from them on the following morning. But none of these larvæ would fasten on the gills that were already occupied by glochidia.

In wandering about the aquarium the larvæ necessarily came in contact with both kinds of gills, but would not fasten on those that had glochidia. Hence there must be something in connection with the glochidium-infected gill that becomes manifest to the copepodid larva and exerts upon it an antagonistic influence. What this is it would be very difficult to decide, but it would seem as if it must influence the larva through sensations corresponding either to smell or taste.

And the antagonism is not all in one direction; the presence of copepodid larvæ proves fully as distasteful to the glochidia as does that of the glochidia to the larvæ. On the gills above mentioned that were well infested with copepodid larvæ no glochidia were found, or if present they were in such small numbers (one to four) as to prove the general statement still more forcibly. Some of these fish must have had the same chance as the others to become artificially infected with glochidia; the very fact that they were caught and brought in for examination proved this.

Finally to complete the evidence about a dozen fish were found with a respectable infection of both glochidia and copepodid larvæ, about half a dozen of each. This would seem to indicate that the antagonizing influence, whatever it may be, can not be spread over the entire gill by a few parasites of either kind, but that it requires a dozen or more.

When the smaller number is present the antagonism is incomplete and both kinds may be found upon the same gill, but when the larger number is present the antagonism becomes complete and one kind of parasite occupies the gill to the exclusion of the other.

Two conclusions naturally follow from these observations, the one being the reverse of the other:

1. If conditions occur which are peculiarly favorable to the copepods and they increase so as to be present in considerable numbers on the gills of all the fish, then artificial infection with mussel glochidia will be seriously hindered and may even be a failure.

2. But evidently this artificial infection with glochidia and any natural infection that may occur will operate as a preventative against the increase of the copepod parasites, and if persisted in might reduce their numbers almost to extinction. At all events among fishes kept for the purpose of breeding mussel glochidia there will be very little danger of such an epidemic of copepod parasites as often occurs in trout ponds and aquaria, due to excessive development.

Geographical distribution of species.—Of the 17 species here enumerated 9 (53 per cent) are from our North American rivers and lakes, 4 (24 per cent) are from Africa, 3 (17 per cent) are from Europe, and a single one (6 per cent) is from South America. The following list gives the names of the species found on the respective continents:

North America: *anomala*, n. sp., *catostomi*, *cruciata*, *dolabrodes*, n. sp., *pectoralis*, *pomotidis*, *tenuis*, *tortua*, *variabilis*.

Africa: *barnimii*, *diceracephala*, *haplocephala*, *temnocephala*.

Europe: *cyprinacea*, *esocina*, *phoxinacea*.

South America: *lagenula*.

Cunnington stated: "So far as I am aware, the existence of the genus in Africa has never been put on record before" (1914, p. 819).

But *barnimii* was captured in 1860 at Dabbeh on the River Nile in Nubia. The single South American species is probably not a fair representation of the genus on that continent, but simply means that there has not been very much search for these parasites upon South American fishes.

Similarly, the nonappearance of Asia in the above list must not be interpreted as excluding the genus from that continent. Practically none of the fresh-water fishes belonging to that region has ever been examined for parasites, and there is no obvious reason why the genus should not be represented there as well as elsewhere.

Hosts.—This entire genus and the single known species of the genus *Sylvestria* are the only Lernæans which infest fresh-water fishes, but they are widely distributed amongst the different families of fishes, as can be seen from the table which follows.

Moreover, it will be noted that if the larvæ thus far discovered can be taken as typical of the entire genus, every species of *Lernæa* has at least two hosts, widely differing from each other. One of these serves as the temporary host of the copepodid larvæ, the other as the final or permanent host of the adult female. Our knowledge of the larvæ of the different species is at present too limited to enable us to draw any general conclusions with reference to the relations between the temporary and permanent hosts. But it is worthy of comment that both kinds of hosts include fish which frequent the surface, others which frequent the bottom, and a third class which may be found at almost any depth.

Probably later investigation will discover some general relation between these; it would at least seem reasonable that the two hosts of the same species should be fishes that frequent similar localities.

Host species.	Parasite species.
Ambloplites rupestris (redeye)	*cruciata*, adult female.
Ameiurus nebulosus (bullhead)	*tortua*, adult female. *pomotidis*, copepodid larvæ.
Aplodinotus grunniens (sheepshead)	*tenuis*, adult female.
Barbus bynni (fish of River Nile)	*temnocephala*, adult female.
Catostomus nigricans (hog sucker)	*tortua*, adult female.
Clarias mossambicus (fish of River Nile)	*diceracephala*, adult female.
Cyprinus carassius (carp)	*cyprinacea*, adult female.
Esox lucius (pike)	*cyprinacea*, adult female. *esocina*, adult female.
Eupomotis gibbosus (sunfish)	*cruciata*, adult female.
Gasterosteus aculeatus (stickleback)	*esocina*, adult female.
Labeo niloticus (fish of River Nile)	*barnimii*, adult female.
Lepomis pallidus (bluegill)	*variabilis*, adult female. *dolabrodes*, adult female. *pomotidis*, adult female.
Lepisosteus platostomus (short-nosed gar)	*variabilis*, copepodid larvæ.
Lota vulgaris (burbot)	*esocina*, adult female.
Micropterus salmoides (largemouth black bass)	*cruciata*, adult female. *anomala*, adult female.
Moxostoma macrolepidotum (large-scaled sucker)	*cruciata*, adult female. *catostomi*, adult female.
Notropis cornutus (shiner)	*pectoralis*, adult female.
Perca fluviatilis (perch)	*esocina*, adult female.
Phoxinus marsilii (minnow)	*phoxinacea*, adult female.
Polypterus birchir (fish of the White Nile)	*haplocephala*, adult female.

Host species.	Parasite species.
Polypterus congicus (fish of Lake Tanganyika)	*haplocephala*, adult female.
Polypterus senegalis (fish of the White Nile)	*haplocephala*, adult female.
Rutilus rutilus (European roach)	*esocina*, adult female.
Stizostedion canadense (sauger)	*cruciata*, copepodid larvæ.

Food.—Whatever discussion there may be as to the food of copepod parasites belonging to other families, it would seem as if there was no room for any question among the Lernæidæ. When a parasite breaks through the skin of its host and burrows into the underlying tissues, we can only conclude that it is in search of suitable food. Moreover, since the tissues themselves are not destroyed, the blood and the lymph which bathes the tissues are the only possibilities left, and these make up the food of the present genus.

Economic relations.—The deliberate burrowing of the parasite into the flesh of the host must cause the latter keen torture, and it will be noted that the list of hosts includes many of our game fishes. If this genus ever became abundant it would furnish a serious menace to our fresh-water fisheries. But fortunately it is held in check in many ways, so that there is little danger of its accomplishing much harm.

During the two free-swimming periods the larvæ are a part of the plankton and are subject to all its dangers and vicissitudes. The first of these periods includes both the nauplius and metanauplius stages, while the last includes the final copepodid stage, or so much of it as is occupied in the search for the final host. Thus the entire time during which the larva swims about freely is much longer than in the Lernæopodidæ and approaches closely to that of the Caligidæ.

Again the necessity for two hosts operates against the genus; if it is difficult to find one host it is twice as difficult to find two. And the ratio is increased by the possibility that the larva may be carried by the first host where it can not find the second one. The more complicated the life history the more numerous are the chances of failure. And the species of the present genus, together with the other Lernæans, have the most complicated development amongst all the parasitic copepods. All these things operate so much against them that they are the least numerous of the parasites; one may often examine hundreds of fishes without finding a single specimen of the genus. And they never occur in any considerable numbers upon a single fish; one specimen to each host is by far the most common mode of distribution.

EXTERNAL MORPHOLOGY.

The morphology of the genus has already been well worked out by Brühl, Claus, Hartmann, and others, but they used only what could be seen through the body wall or discovered by ordinary dissection.

So far as known no investigator has ever employed serial sections or double staining. These agents bring out many additional facts, explain others that have heretofore seemed obscure, and modify considerably some of the interpretations that have been given. In order that the present account may form a complete whole the substance of what was published by the above-named authors is here included in a condensed form and to it are added the new facts and explanations.

General body form.—The body of the adult female is made up of three parts or regions—the cephalothorax, the free thorax, and the abdomen. (See fig. 69, pl. XIV.)

Dorsally the head is well differentiated from the first thorax segment, but ventrally the two are completely fused. From the sides and sometimes from the dorsal surface of the (fused) first thorax segment soft horns, more or less branched, extend outward and serve to anchor the parasite in the tissues of the host. The free thorax starts as a slender neck, which increases gradually in diameter backwards, making the trunk of the creature club-shaped. At the posterior end the dorsal portion of the thorax passes insensibly into a short abdomen, which is much narrower than the thorax, bluntly rounded, and tipped with a pair of tiny anal laminæ.

On the ventral side the thorax is abruptly narrowed to the diameter of the abdomen, leaving a bluntly rounded protuberance for which Cunnington has proposed the name of "pregenital prominence."

The egg cases are attached to the ventral side of the thorax just in front of the base of the abdomen; they are oval or elliptical in outline and much shorter than the body. The eggs are large, spherical, and not flattened; they are multiseriate, but have no definite arrangement.

Torsion.—During the process of burrowing into the fish's tissues the body of the parasite usually becomes twisted upon its longitudinal axis, so that the pregenital prominence, instead of being on the ventral surface with the mouth and the appendages, is turned to one side and may even be carried through 180°, so that it apparently lies on the opposite or dorsal surface of the animal.

Quidor has described this arrangement in a recent paper on some of the other Lernæidæ and has named it torsion. He called the torsion direct when it turns from the left over toward the right, looking at the animal from the anterior end, and inverse when it turns from the right over toward the left. He claimed that one kind of torsion was shown when the parasite was attached to the left side of the fish and the other kind when it was attached to the right side, and that the amount of torsion was constant for a given species. The author has disproved this claim for other genera in the Lernæidæ,[a] and the few data available for this genus are all against it.

The first adverse fact is the existence of altogether too many full-grown adults without any torsion at all. An occasional specimen of this sort would only furnish the usual exception that occurs with every rule. But in the data given below 8 specimens of *cruciata* out of 20 showed no visible torsion, namely, 40 per cent of the whole.

Claus in dealing with *L. esocina* noted that young forms 3.50 mm. long possessed straight bodies on which the four pairs of swimming legs were in the same straight line and that the twisting took place gradually during subsequent growth[b] Evidently it frequently happens that there is no subsequent twisting, for every one of the eight specimens just mentioned was 15 to 20 mm. long and carried egg strings.

In the second place, specimens obtained from the same fish do not show the same torsion. A single 9-inch largemouth black bass, *Micropterus salmoides*, was obtained at Fairport, Iowa, which was infested with eight specimens of *L. cruciata*, two on the right side, five on the left, and one on the median line behind the dorsal fin. Of the first two one showed direct torsion of 180° and the other inverse torsion of 150°; the single parasite on the median line showed an inverse torsion of 180°; of the remaining five, two showed direct torsion of 135° and 180°, respectively; and the other three inverse torsion of 150°, 180°, and 180°. Thus neither the amount nor the kind of torsion was constant, but it might be objected that the maximum difference is only 45° and that five out of the eight specimens did show a torsion of exactly 180°. But even three out of eight, 37 per cent, is still too large a number to be treated as mere exceptions, and this proportion is greatly increased in the following data.

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[a] Proc. U. S. Nat. Mus., vol. 53, p. 10.

[b] Schrift. Gesellsch. Beförd. ges. Naturw. Marburg, vol. 9, supplement, p. 2, 1868.

The detached specimens in the National Museum collection were examined for the kind and amount of torsion, but of course nothing could be told as to which side of the fish they came from.

Four specimens of *L. tortua*, all from the same fish, showed torsions of 45° inverse, 90° inverse, 720° direct (two complete revolutions), and 90° inverse, respectively. Five specimens of *L. variabilis* from different fish showed respective torsions of 45° inverse, 90° inverse, 0°, 100° inverse, and 45° inverse. In 20 specimens of *L. cruciata* from different fishes, all the same size and carrying egg strings, there were 8 that showed no torsion at all, 4 that showed 180° direct torsion, 2 that showed 180° inverse torsion, while the torsions of the other 6 were, respectively, 150° inverse, 45° direct, 25° direct, 25° inverse, 100° direct, and 20° direct.

A single specimen of *tortua* from *Micropterus salmoides* at Black Creek, N. C., had its body twisted inversely in three complete revolutions (1080°) just behind the cephalothorax. (See fig. 4, pl. VI.) In view of such extreme differences, the only rational conclusion is that neither the amount nor the kind of torsion possesses any systematic value whatever.

The cephalothorax.—At the anterior end of the cephalothorax, between the bases of the anterior horns, is a small button-shaped projection, its posterior margin fused with the dorsal surface of the cephalothorax, its anterior margin projecting freely, its dorsal surface more or less strongly convex. This may be called the head or cephalon and it carries on its anterior free margin the two pairs of antennæ, which are very similar in all the species of the genus. (See fig. 5, pl. VI.) The first antennæ are three or four jointed, not including the basal protuberance to which they are attached, which is entirely lacking in some species and which is immovable when present. Every joint is heavily armed with long plumose setæ along its anterior margin. Claus and some of the older investigators ascribed five joints to these antennæ, but their illustrations show that they counted the basal projection as a fifth joint. (See fig. 42, pl. XI.)

The second antennæ are two jointed, again omitting the basal projection; the proximal joint is unarmed, while the terminal joint ends in a tuft of setæ and a single large curved claw, making these appendages uncinate and attesting their prehensile function. The same remarks apply to these appendages as to the first pair, Claus and others designating them as three jointed. (See fig. 43, pl. XI.) The anterior margin of the head projects between these antennæ as a more or less pointed rostrum.

In the center of the dorsal surface of the projecting head lies a proportionally large eye, made up as in other parasitic copepods of three parts. The paired lateral portions each surround a large spherical lens, while the unpaired anteroventral portion contains a retinal layer of dark pigment. (See fig. 2, pl. VI.) In *L. barnimii* Hartmann described the eye as located on a special flattened plate on the dorsal surface of the head; the three refractive bodies were spherical and of about the same size, and the unpaired one was posterior. In *L. esocina* according to Claus and in all the American species examined the paired lateral portions are much larger than the unpaired central one, and the latter is anterior and ventral. Often nothing can be seen of this optical apparatus in external view since it is buried some little distance beneath the skin and lies just above and posterior to the supra-œsophageal ganglion. But in preserved and cleared material as well as in serial sections it is always distinctly visible. (See fig. 65, pl. XIII.)

Below the rostrum and between the antennæ on the ventral surface of the head is a short proboscis. Here again there has been diversity of opinion among the different investigators. Burmeister and Hartmann described a proboscis, while Claus and Brühl declared that there was none present. If by the term "proboscis" is meant a rigid sucking tube constantly projecting some distance from the ventral surface of the head, Claus and Brühl were right; there is nothing of the sort. But if we may designate as a proboscis the upper and under lips and some of the soft tissue connecting them, which can be protracted and withdrawn at pleasure, then Burmeister and Hartmann were correct, for there is such a proboscis, corresponding in its general make-up to that in the genus *Lernæenicus* and some other Lernæan genera.

A careful examination of the musculature connected with this proboscis, as shown in figure 7, leaves no question as to the possibility of its protrusion and withdrawal. (See p. 179.)

Claus demonstrated a chitin framework supporting the softer parts of the mouth tube in *esocina*, and this is found also in other species. The dorsal portion of this framework is formed by the upper lip, which is comparatively broad and is attached to the front of the head between the bases of the antennæ. The rest of the framework consists of a narrow chitin ring fused on either side to the lateral margin of the upper lip and supported on the ventral surface by a pair of stout rods, which extend obliquely backwards and outwards in the integument. (See fig. 76, pl. XIV.) The lower lip is in the form of a pad, attached to the outer surface of the mouth tube and articulated with the chitin ring in such a way as to allow of considerable motion backwards and forwards. This motion is accomplished by four longitudinal muscles, which extend backwards from the lower lip along the ventral surface.

The mouth parts.—Inside the mouth tube and between the two lips lie the mandibles, each of which is one jointed and strongly curved, with a sharp spinelike point and without teeth. These mandibles were discovered, described, and figured by Claus, but have been overlooked by the other investigators. They are difficult of detection and require the previous removal of the maxillæ and maxillipeds before they can be seen. The mandible of *variabilis* is curved more strongly than that of *esocina* and is clearly shown in figure 50.

The first and second maxillæ are attached to the outside of the mouth tube between the upper and under lips. Each consists of a stout basal joint and a movable terminal claw; in the first pair the claw is single, in the second pair it is double. Both pairs of maxillæ converge inwards across the tip of the mouth tube, so that the claws meet on the median line. (See fig. 5, pl. VI.)

The maxillipeds originate some distance behind the mouth tube upon the ventral surface of the cephalothorax. Each is made up of an elongated basal joint, which carries on its inner margin at the distal end a papilla tipped with a long plumose seta, and a terminal joint armed with five curved claws and a tuft of setæ. The number of parts in these maxillipeds is apparently constant for all the species, the specific differences being confined to relative shape and size.

The swimming legs.—There are five pairs of swimming legs which are variously disposed upon the body in the different species. A table has already been published [a] showing the relative distances between the successive pairs of legs in the North American species, and that table is repeated here with the addition of the two new species.

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[a] Bulletin, United States Bureau of Fisheries, vol. 34, 1914, p. 370.

In this table the entire length of the parasite, excluding the egg strings, is called 100. The distance of each pair of legs from the anterior end is reduced to the proper percentage of 100, so that a comparison of the figures one with another gives the actual relative position of any pair of legs on any species.

Species.	First legs.	Second legs.	Third legs.	Fourth legs.	Fifth legs.
Anomala	3	4	29	56	74
Catostomi	4	8	48	80	....
Cruciata	10	15	42	75	....
Dolabrodes	7.5	10	38	70	98
Pectoralis	7	13	33	60	93
Pomotidis	12	38	52	88	....
Tenuis	7.5	11	35	70	....
Tortua	5.5	7	30	70	....
Variabilis	4	8	30	70	96

These relative distances are not claimed to be constant for any given species, but probably vary within certain limits; such individual variations, however, are likely to be considerably less than the specific variations given in the table. The gradual increase in these distances from in front backward shows that in the final elongation of the body after attachment to the host every free thorax segment has a share.

The anterior segments are not elongated as much as the posterior, but each contributes something. In the other genera of the Lernæidæ the bunching of the legs just behind the head shows that the great bulk of the elongation is contributed by the fifth and sixth segments.

Of the first four pairs of legs each is biramose and made up of a broad basal joint and two slender three-jointed rami. On the inner margin of the basal joint the first legs carry a stout claw, the other three pairs a single plumose seta. There is a fifth pair of legs just in front of the external openings of the oviducts; each leg is composed of a single hand-shaped joint armed with setæ. These legs do not get broken off in the mature female as easily as in the other *Lernæan* genera, where they are all bunched closely together.

Claus first called attention to the fact that these swimming legs neither degenerate nor disappear, contrary to the usually accepted understanding of the Lernæidæ. There is no diminution in size, in the number of rami or joints, or in the plumose setæ with which they are armed. The legs simply remain exactly as they were at the close of the copepodid stages when the parasite sought out its final host. They do not develop in accordance with the enormous increase in the size of the thorax and abdomen; but neither do they lose anything, not even a single seta of their armature, and hence they can not be said to degenerate. Similarly, the only disappearance is one due to breakage consequent on the burrowing habits of the parasites, which is a very different thing from degeneration.

The swimming legs are situated in transverse shallow grooves which mark the dividing lines between the thorax segments, the anterior slope of the groove being a little higher than the posterior. Each pair of legs is joined across the median line by a transverse rib, which lies just in front of the groove and is thoroughly fused with the body wall.

Owing to the torsion of the body only the anterior pair of legs lie symmetrically upon the median line. The others are carried more and more to the right or left until the fourth pair come to lie apparently on the side of the body, or may even be twisted so far that they appear to be on the dorsal surface. Really, of course, all the legs are on the ventral surface, and we must conceive of the longitudinal axis as twisted equally with the body itself. The apparent position of the legs thus affords a ready means of measuring both the direction and the amount of the torsion. (See fig. 68, 75, pl. XIV.)

The abdomen.—This is a short blunt cone on a level with the dorsal surface of the genital segment and ending in two minute anal laminæ. (See fig. 69, pl. XIV.)

These are so tiny that they escaped the notice of all the earlier investigators but are very distinct, and each is armed with a long plumose seta with a much shorter nonplumose one on either side of it.

The abdomen shows no other processes or appendages.

INTERNAL MORPHOLOGY.

The skin.—The integument is made up of three layers, the outer one hard, the two inner ones soft. In the present genus the outer layer never becomes really chitinous, as it does in some of the other Lernæids (*Hæmobaphes*, *Lernæolophus*, etc.). It is yellowish brown in color and offers considerable resistence to the penetration of fixatives.

It shows in a cross section (fig. 8, pl. VII) that it is made up of thin layers of lamellæ, many (7 to 10) of which are packed together one over another. These lamellæ lie in contact with one another and show no such intervening spaces as were noted in one instance by Hartmann. Neither do any of the species examined by the present author show the delicate surface markings seen by Hartmann on the outer lamella of *L. barnimii*. But it should be added that Hartmann examined living material while in the present instance only preserved material was used.

This lamellar layer of the integument is perforated by pore canals (*pc*), which are more numerous in the center and posterior portions of the body and less numerous at the anterior end and on the horns and appendages.

Each canal is a tolerably thick-walled tube, the outer surface of the walls being finely wrinkled transversely, while the inner lumen is perfectly smooth. The outer and inner openings of the canals are slightly larger than the central lumen, and in the posterior body and horns the external surface of the canals at the outer opening forms a six-sided polygon around the circular lumen, as stated by Hartmann.

The pregenital prominence.—In lateral view this prominence forms a sort of heel, the abdomen a sort of toe, while the free thorax is the leg of the boot, as was first suggested by Nordmann. Claus stated that in *L. esocina* the posterior part of the body first assumed the boot-shaped bending at the beginning of sexual maturity. He ought rather to have said at the completion of sexual maturity, for as we can see from the life history here given sexual maturity begins and becomes so far developed as to allow of impregnation during the copepodid stage, while the boot shape is not assumed until the creature has reached its maximum length. (See fig. 68, pl. XIV.)

Inside of this external layer of the integument is a single, comparatively thin layer of polyhedral cells (*hy*), whose walls and nuclei are very clearly marked. This is the first of the inner soft layers and corresponds to the "hypodermis" of Claus or the "chitinogen layer" of Hartmann and other authors. It is much softer than the outer layer, the cell contents are fine grained, and both nuclei and nucleoli are distinctly visible.

This layer extends without change or interruption over the inner ends of the pore canals, showing that the latter are not to be regarded as ducts, each connecting with a specific glandular body, but rather the entire inner layer is probably glandular and shares all the pore canals in common. This view is strengthened by the presence, inside the hypodermis and firmly adherent to it, of the second soft layer, several times as thick, indistinctly separated into cells, and containing a coarse protoplasmic network with numerous irregularly disposed nuclei, sometimes single and sometimes gathered into bunches (*il*, fig. 8, pl. VII).

This layer has all the characters of glandular tissue and varies considerably in thickness, being thickest where the pore canals are most numerous, especially at the pregenital prominence. (See fig. 13, pl. VII.)

Here the cells are much more distinct, in fact they are usually entirely separated one from another, and each is multinucleated.

This layer is entirely lacking in the head, the arms, and the appendages, or just the places where the pore canals are fewest in number.

The digestive canal.—The mouth opens directly into the œsophagus, which is cylindrical and short, and extends diagonally downward to the stomach, from which it is separated by a powerful sphincter muscle.

The walls of the œsophagus (*oe*, fig. 7, pl. VII) are tolerably thick and are connected with the dorsal and ventral walls of the head and with the stomach walls by powerful muscles (*m*), which must be capable of widening the lumen of the œsophagus and thus producing a suction through the mouth. Such a widening would produce the so-called "crop" described and figured by Hartmann in *barnimii*, which thus becomes a temporary condition of the gullet rather than a permanent portion of the digestive apparatus. Between the horns the stomach widens and sends out a lateral lobe on either side toward the bases of the horns but not actually reaching them. It then narrows and passes insensibly into the intestine, whose anterior portion is often thrown into numerous convolutions (fig. 9, pl. VII), and which maintains a wide lumen throughout the entire body. At the pregenital prominence the intestine is abruptly narrowed into the rectum, which is spindle shaped, widened through the center, and very narrow and slitlike at the posterior end (*rc*, fig. 10, pl. VII).

The wall of the stomach-intestine is made up of an outer muscular layer and an inner epithelium, and the latter has the same structure as in other parasitic copepods, larger digestive cells being interspersed among the epithelial cells. (See fig. 62, pl. XIII.) But there are also in the epithelium of the stomach and one or two of the anterior convolutions of the intestine numerous scattered cell bodies, which are totally unlike anything found in the other families of copepods. They are spherical in shape and possess a comparatively large and very distinct nucleus and nucleolus.

The body of the cell outside the nucleus is filled with small granules, sometimes colored greenish or brownish, mixed with which are larger colorless refractive bodies. These may be spherical, angular, boat-shaped, buckle-shaped with a crossbar through the center, or simply irregular and strongly granulated. Hartmann suggested that these might be psorosperm, whose existence in the epithelial cells of the intestine was abundantly proved by Leuckart, Wagener, and Reincke.

Considering that these parasites burrow into the tissues of fish and feed upon the blood and juices found there, it would be strange if they did not obtain some psorosperm.

The transverse muscles of the walls of the intestine and rectum are comparatively powerful and produce a strong peristaltic movement. This is the principal factor causing the weak currents in the fluid filling the body cavity, which constitute the only circulation that the creature possesses.

The muscles.—Although the body of these parasites is quite distinctly segmented, there can be no movements of the segments one upon another, because there are no muscles to produce such movements. Here there has been a positive degeneration, and the system of body muscles which was present and operative in the copepodid larva at the time it attached itself to its final host entirely disappears in the adult.

The only muscles left are those connected with the head, the proboscis, the appendages, the vulvæ, and the anal papillæ. In the head there are two dorsal extensors which move the entire head from above downward, and thus hold it against the tissues of its host, and two ventral retractors which lift it up again. Similar extensors and retractors are connected with the proboscis, the antennæ, and the mouth parts.

Each pair of swimming legs retains the strong muscles which they originally possessed in the copepodid stage, including those connecting the basal joints with the inner walls of the body, those moving the respective joints of the rami, and those which operate the various swimming setæ.

Even the fifth legs retain the rudimentary muscles, which are all that they ever possessed. The muscles connected with the vulvæ are similar to those found in other copepod families, especially the Lernæopodidæ, and are the ones controlling the passage of the eggs out into the external sacks. The muscles which move the anal laminæ radiate from the bases of the laminæ to the surrounding walls of the abdomen. All these muscles are distinctly striated and are made up of bundles of fibrillæ.

The nervous system.—The copepodid larvæ possess a normal crustacean nervous system. (See fig. 62, pl. XIII.) How far is this system modified or changed in the adult? This question has not been answered by any of the investigators who have worked with the present genus, for they knew nothing of the larva, and the nerves of the adult are easily overlooked.

In the first place it is evident that the muscles we have just described must have some nerve center to control their movements. This is especially true of those in the head, which move the head itself, the antennæ, and the mouth parts. The need of a proper control of these muscles is even greater in the adult than in the larva, for they are all concerned in procuring food, so essentially necessary for the rapid and comparatively enormous growth from the larva into the adult, and for the formation and nourishment of the eggs after the creature has attained its maximum size. Accordingly, we find in the head some very respectable remnants of the supra-œsophageal and infra-œsophageal ganglia. (See fig. 7, pl. VII.) While the outer portions of these ganglia are frayed and indistinct, those portions nearest the œsophagus are well preserved, their nuclei are distinct, and there are still commisures connecting them around the œsophagus. A good optic nerve can be detected leading from the supraganglion to the eye and others to the antennæ and mandibles, while the infraganglion supplies the remaining mouth parts. A distinct ventral cord can not be detected, either in longitudinal or cross section, but both the reproductive and digestive organs must be connected with a nerve center in order to perform their functions aright. In general, therefore, we may say that the nervous system has not developed in accordance with the rest of the body.

The œsophageal ganglia and their commisures have increased in size from the copepodid stage, but the nervous elements in the adult are not as clearly defined or relatively as well developed as they were in the larva. The peripheral portions of the ganglia are broken and jagged, and the large ventral trunk into which the infraganglion was prolonged is so much reduced in size that it can not be followed into the free thorax with any degree of certainty.

The reproductive organs.—Claus and Hartmann both gave a very brief account of the reproductive organs, but as they drew their information from an examination of entire adults, so that their observation of the structure of these organs was made from the outside through the body wall, their description was both scanty and inaccurate in many particulars.

Claus[a] said: "The sex organs correspond in position and form with those of the Lernæopodidæ. Drawn back out of the cephalothorax, they fill the widened posterior portion of the body, and are made up of two symmetrically placed ovaries with attached oviducts and the same number of tubular cement glands."

Hartmann[b] said: "The sex organs are made up of two simple sacklike ovaries which occupy the last quarter of the posterior body. The wall of the same was very contractile, but I could not make out the structure." In the Lernæopodidæ, as shown by the author,[c] the ovaries are short, spherical masses of cells situated between the stomach and the dorsal body wall, partly in the first (cephalothorax) and partly in the second thorax segment, and the oviducts are given off from their posterior ends. Here, on the contrary, the ovaries are elongated and spindle-shaped, flattened dorsoventrally, and situated as Hartmann said "in the last quarter of the posterior body," namely, in the fifth thorax segment. They lie between the intestine and the dorsal body wall; posteriorly they taper to a sharp point, which is suspended from the dorsal wall by two short bands of striated muscle; anteriorly they are narrowed into the oviducts which turn down ventrally around the outside of the intestine, and in young females proceed straight back along the ventral surface to the vulvæ. (See fig. 10, pl. VII.)

In older females loops are formed in the oviducts coincident with the development of the eggs, until in a fully ripe female each oviduct turns backward along the dorsal surface of the intestine as far as the base of the abdomen, then forward nearly to the anterior end of the fourth segment, then curves around to the side of the intestine and runs backward to the vulva, just behind the pregenital prominence. (See fig. 11, 12, 14, pl. VII, VIII.)

On examining sections of the ovary under a higher power, the pointed posterior end is seen to be filled with a mass of genital protoplasm containing numerous scattered nuclei, but without definite cell structure.

Proceeding forward the protoplasm gradually breaks up into rounded masses, each containing many nuclei. (See fig. 15, pl. VIII.) A little farther forward these masses are divided transversely into separate cells, discoidal in shape and packed like rows of coins, each with its own nucleus, which is now much enlarged and provided with a nucleolus.

At the anterior end of the ovary where these egg filaments pass into the oviducts the individual cells are separated from one another, and each oocyte thus set free absorbs food or yolk material, swells into a sphere, and becomes eventually a mature egg. (See fig. 16, pl. VIII.)

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[a] Schrift. Gesellsch. Beförd. ges. Naturw. Marburg, vol. 9, supplement, p. 10, 1886.

[b] Arch. Anat. Pnysiol., p. 749, 1870.

[c] Proc. U. S. Nat. Mus, vol. 39, p. 219, 1910.

This formation of the egg differs from that of the Lernæopodidæ in that the egg filaments are much larger, and while in the Lernæopods the terminal oocyte alone develops with the rest of the filament still attached to it, here the whole filament breaks up and its integral oocytes develop simultaneously. But the resultant egg is practically the same in the two families. A thin and structureless vitelline membrane is distinctly visible around the newly formed egg. Inside of it the entire substance of the egg is made up of yolk globules evenly distributed throughout a matrix of finely granular protoplasm.

These globules are spherical or ellipsoidal in shape and differ but little in size; they are loosely packed together without being flattened, and without leaving the vacuoles seen in Lernæopod eggs, although these appear later. (See fig. 20, pl. VIII.) The egg nucleus is a little ellipsoidal, comparatively large, and contains a single large spherical nucleolus, without any chromatin granules. This nucleus is surrounded by a well-defined membrane and may be situated indiscriminately anywhere within the egg, as were the nuclei of the oocytes in the egg filaments.

The eggs pass down the oviducts in a single or sometimes a double row, with practically no flattening at all, or when there is any, it is fully as often lateral as longitudinal. This is very different from what is found in the other Lernæids, where the eggs are packed so tightly in a single row inside the oviduct that they are flattened lengthwise into thin disks or wafers. And they pass out through the vulvæ and assume the same shape and arrangement in the external sacks. Here, on the contrary, they pass loosely into the external sacks, where they are arranged in many rows, without any definite order and without being at all flattened.

There is no separate cement gland, but the posterior portion of the oviduct acts in that capacity. From the vulva to about the center of the fifth segment the oviduct is slightly narrowed and its walls are greatly thickened. Elsewhere structureless except for the muscle fibers they contain, the walls here become definitely glandular and secrete the cement substance. (See fig. 17, pl. VIII.) At the point where this change in structure occurs there is a constriction in the oviduct and also an S-shaped curve in its direction. The eggs striking this constriction are fertilized and then pass through the glandular portion in single file, being covered with a layer of the cement substance during their passage. There is no semen receptacle connected with the oviduct, at least none is revealed either in gross examination or in sections, and hence it is impossible to prove just where the eggs are fertilized. Nor should we expect to find any, for the spermatophores are fastened by the male directly to the vulvæ, and their contents are discharged into the oviducts. It is therefore only a question of how far up the oviducts they go, and it would seem most reasonable to suppose that they reach the portion just above the glandular walls.

The sperm would not likely be mingled with the cement substance in the glandular portion of the oviduct, and if the eggs were fertilized very much above this portion they would not be fully matured.

The cement substance forms a thick outer membrane around the egg, separated a little from the vitelline membrane and stiffening into a tough covering. The egg sack itself is formed of the same material, and inside of it there are no secondary walls separating the individual eggs, as in the other Lernæidæ. The two membranes covering the egg are separated a little, and this together with the loose arrangement of the eggs in the sack secures enough free space around each egg to supply the requisite oxygen for the developing embryo.

EMBRYONIC DEVELOPMENT.

Segmentation.—Because the eggs are not regularly arranged in the external sacks there is a corresponding irregularity in the position of the embryos. In consequence of lack of material it has not been possible to follow the various cleavage stages as fully as in the Lernæopodidæ.[a] But the few stages that have been obtained corresponded exactly with those found in the Lernæopods, and there is thus a strong probability that the other stages also correspond. At all events it is safe to say that cleavage in this genus resembles that in *Achtheres*, *Clavella*, and *Brachiella* far more than it does in *Lernæocera* (*Lernæa*) as given by Pedaschenko (1898).

Blastula.—The blastula shown in figure 20 is practically identical with that of *Achtheres*,[b] the only difference being an increased thickness of the blastoderm disk.

The yolk here shows that all of the cytoplasmic material has migrated to the surface and entered into the blastoderm. Now, also, there are good-sized vacuoles in the yolk, possibly as a result of this withdrawal of material. There is no evidence in any of the sections of the formation of a blastodermic cuticle similar to that secreted by the *Achtheres* embryo. Further material may reveal the presence of such a cuticle, but its absence seems fully as much in accordance with the subsequent development of the present genus. For we do not have here a shifting back into embryonic life within the egg of the early stages of development, such as occurs in *Achtheres*.

In that genus all of the nauplius and metanauplius stages are passed within the egg, and the larva hatches either in the last metanauplius stage and molts within an hour into the first copepodid stage or hatches directly into the latter stage. Here, on the contrary, the larva hatches into an ordinary nauplius and none of the early stages are passed inside the egg.

THE NEWLY HATCHED LARVA.

Nordmann, Brühl, and Hartmann have given us figures of a newly hatched larva (fig. 22, pl. IX), but Brühl's figure was simply a copy of Nordmann's, and Brühl himself had never seen a larva. Of the other two figures, Nordmann's is by far the better and is accompanied by an excellent description. Hartmann showed a series of eggs taken from the egg sack in various stages of development and also a "free larva." But he gave no description, and the larva which he designated as "free" had four pairs of appendages instead of the three shown on another larva just emerging from the egg membranes. The former, therefore, probably represented a larva that had had at least one molt, and hence was not newly hatched.

Nordmann stated that he actually witnessed the emergence of the larva, inclosed in its two membranes, from the egg sack, the bursting of the outer membrane, and the swelling and rupture of the inner membrane.

Since his figures of the corresponding larvæ of the genus *Achtheres* were wonderfully correct, we can accept these of *Lernæocera* on the same basis. According to his account the larva was a nauplius with the usual three pairs of appendages. The body was oval or ellipsoidal, with its lateral margins tolerably parallel, and about 0.25 mm. long.

It was covered on both the dorsal and ventral surfaces by a delicate shield or carapace, of a greenish color in that particular species (*esocina*), well arched dorsally, flattened ventrally, and marked with dark-colored longitudinal stripes. The eye was bright red in color.

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[a] Proc. U. S. Nat. Mus., vol. 39, p. 196.

[b] Proc. U. S. Nat. Mus., vol. 39, pl. 29, fig. 8.

A female *L. variabilis* was obtained from a bluegill, and on examining her egg strings the eggs were seen to be ellipsoidal instead of spherical, but showed no pigment, as is the case with most copepod eggs when ready to hatch. On the strength of the difference in shape, however, this female was placed at night in a suitable aquarium, and the next morning all the eggs were hatched.

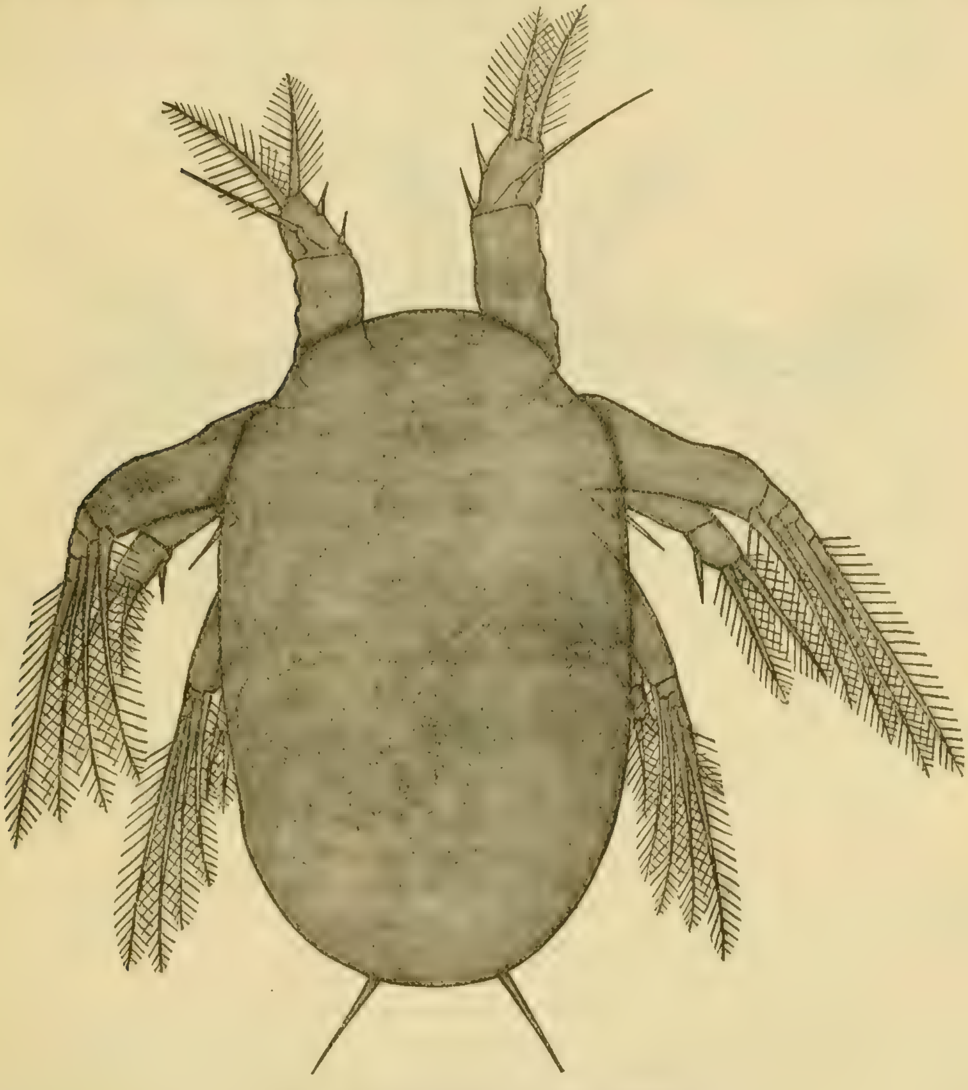

FIG. 1.—The newly hatched nauplius of *L. variabilis*.

Some were examined and the others kept, and they molted during the second night into metanauplii and during the third day into the first copepodid stage, similar in all respects to the one obtained from the gills of the gar. With the stages thus happily obtained we can supplement Nordmann's account and present a complete life history, with every stage figured and described.

The nauplius.—General form elliptical, one-half longer than wide, not narrowed posteriorly, with nearly parallel sides. First antennæ uniramose, two-jointed, basal joint twice the length of the terminal and unarmed, terminal joint tipped with two long, plumose setæ, two short spines on the inner margin, and a long nonplumose seta on the dorsal surface. Second antennæ and mandibles biramose, the exopod four-jointed, with four plumose setæ, the endopod two-jointed, tipped with two plumose setæ, and with a short spine on the inner margin of each joint. The balancers are straight spines, comparatively short and slender, and placed rather close together on either side of the midline. There is no pigment of any sort in this nauplius, no eye is visible, nor is the body transparent enough to show any of the internal anatomy. In these respects it differs from the one described by Nordmann, but is like it in all essentials.

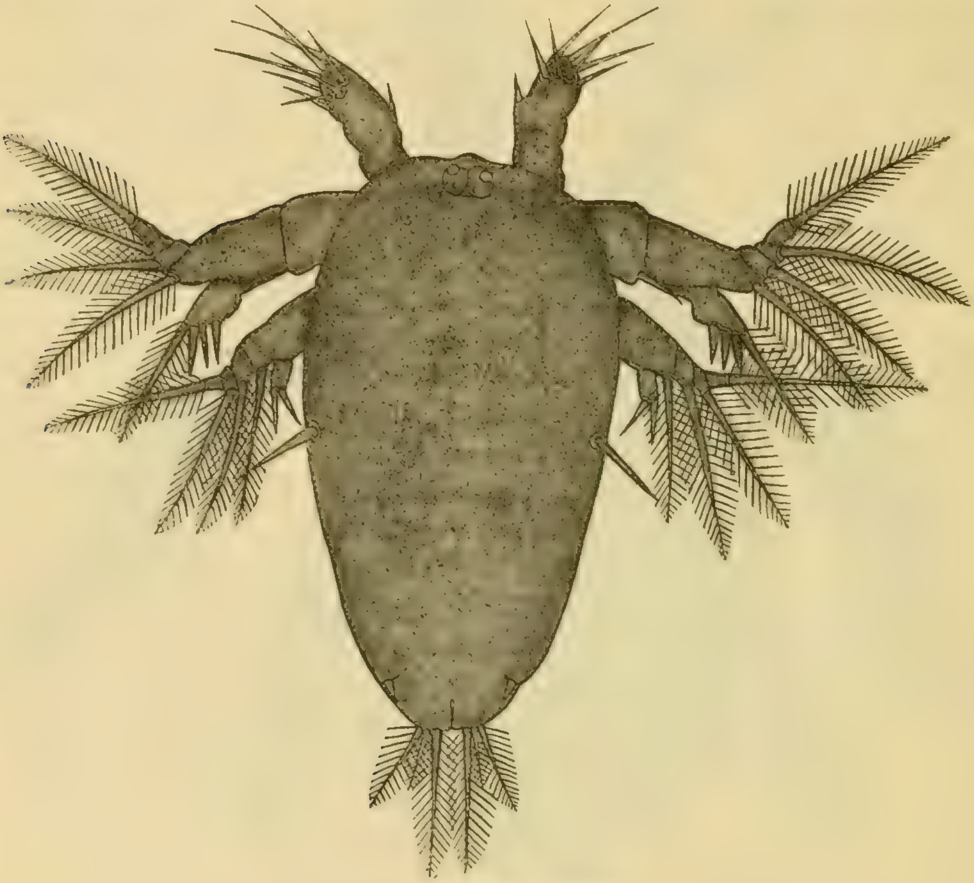

FIG. 2.—The metanauplius of *L. variabilis*.

The metanauplius.—The nauplii molted once and at the second molt passed into a metanauplius stage.

Body elongate, obovate, twice as long as wide, strongly narrowed posteriorly, with evenly rounded margins. First antennæ uniramose and two-jointed, the terminal joint without plumose setæ, but armed with 8 or 10 long spines. Second antennæ and mandibles as in the nauplius, except that the endopod of the second antennæ is now tipped with a single plumose seta, and three large spines on the posterior margin.

Behind the mandibles on the dorsal surface of the body there is a single large spine on either side close to the lateral margin.

Toward the posterior end the swimming legs can be seen partly differentiated inside the body.

At the posterior end are two large anal laminæ, each armed with three plumose setæ, the two inner ones the largest, and the two central ones the smallest.

A compound eye is now distinctly visible close to the anterior margin, and just in front of it that margin projects slightly.

There is no pigment on this metanauplius, and the internal anatomy, with the exception of the eye, is still wholly invisible.

Total length, 0.25 mm. Width, 0.125 mm.

This metanauplius molted once within a few hours, and at the second molt passed into the first copepodid stage some time during the third day.

THE FIRST COPEPODID LARVA.

With the molt from the metanauplius into the first copepodid stage (fig. 31–35, pl. x), the larva ceases its free-swimming life and enters upon its first period of parasitism. It seeks out a temporary host, upon whose gills it can continue its development up to sexual maturity and fastens itself to the outside surface of the gill filaments by means of its second antennæ and maxillipeds. While this attachment is strong enough to hold the larva securely in place even when the gill is rinsed off under a faucet, it can still be easily loosened at the pleasure of the larva. Indeed, these copepodid larvæ are much the most lively parasites of all the copepods infesting fish. It is practically impossible to catch one of them alive without injuring it, for upon being touched they let go of the filament, dart about swiftly in the water, and then seize the gill in another place. But they can often be deceived by cutting off the entire filament and removing it while they still cling to it. Having obtained one in this way from the gills of the short-nosed gar, *Lepisosteus platostomus*, we may examine its structure. It is the larva of *Lernæa variabilis* . (See fig. 31.)

The cephalothorax is elliptical in shape, its longitudinal and transverse diameters being in the proportion of 4 to 3. It is somewhat enlarged through the bases of the first antennæ and the anterior and posterior margins are nearly straight. It is followed by three free thorax segments, which diminish regularly in width, but are of about the same length. Finally, there is a rectangular segment, longer and narrower than the last free thorax segment, which represents the fused abdominal segments. It bears two large anal laminæ at its posterior corners, each armed with a very long and jointed inner seta and four much shorter outer ones, which diminish in size regularly outward.

The first and second antennæ are the same size and each is two-jointed, the terminal joint a little smaller than the basal and heavily armed with setæ. In addition to the setæ the second pair have a strong prehensile claw at the inner distal corner, and they share with the maxillipeds the task of holding the larva in place upon its host.

The mandibles, maxillæ, and maxillipeds are the same in all particulars as those of the adult. Each swimming leg of the two pairs is made up of a short and wide basal joint and two one-jointed rami, well armed with plumose setæ and spines. The first pair of legs is some distance in front of the posterior margin of the cephalothorax and close to the bases of the maxillipeds.

On the lateral margins of the second free joint near the posterior end are the rudiments of a third pair of swimming legs in the shape of small papillæ, each armed with two setæ.

Total length, including anal setæ, 0.53 mm. Carapace, 0.16 mm. long, 0.12 mm. wide.

Color a uniform yellowish white, digestive tube black, eye a reddish purple.

When one of these larvæ molts the old skin cracks open along the back of the thorax and the larva crawls out through the hole thus made, just as a dragonfly or cicada crawls out of its nymph case, and two minutes after emerging it is able to swim about as before.

Some molts occur without any change in the appendages or body segmentation and with only a slight increase in the size of the larva.

THE SECOND COPEPODID LARVA.

In the second copepodid stage (fig. 21, pl. IX) obtained from the gills of the short-nosed gar a new thorax segment has been formed just in front of the genital segment, but the abdominal segments are still entirely fused.

The first antennæ have become four-jointed, while the second pair still remain two-jointed. There are now three pairs of legs instead of two; the first two pairs have two-jointed rami, while in the third pair the rami have but a single joint. The new fourth segment carries at its posterior corners the rudiments of a fourth pair of legs, each consisting of a large rounded papilla and two terminal setæ.

The second (first free) thorax segment has increased until it is fully as wide as the cephalothorax, the third and fourth segments are about the same width, which is two-thirds that of the second segment, and the abdomen has not increased at all.

THE THIRD COPEPODID LARVA.

The third stage (fig. 23-30, pl. IX) was obtained from the gills of the sauger, *Stizostedion canadense*, and is evidently a different species from the one found upon the gar. But it serves just as well to illustrate the changes which mark this stage. Another new segment has been added to the free thorax, the second (first free) thorax segment still remains as wide as the cephalothorax, while the other segments, including the genital segment, diminish regularly in width behind it, though they are all about the same length. The antennæ are four-jointed and two-jointed, as before, but the second pair has increased considerably in length.

There are now four pairs of biramose legs, with the rami two-jointed, and a fifth pair which is rudimentary, each leg made up of two papillæ side by side and tipped with short spines. There is also on either side of the genital segment at the posterior corner a tiny papilla tipped with two small spines, the rudiment of a sixth leg.

The abdomen has lengthened considerably and now has two joints, the basal joint about half the length of the terminal one. There are also many differences in the anal laminæ and their setæ, but these are probably specific differences rather than changes due to advanced development.

THE FOURTH COPEPODID LARVA.

A large number of both sexes of this stage (fig. 53–61, pl. XII) were obtained from the gills of the short-nosed gar, thus completing the larval development, since during this period both kinds of larvæ become sexually mature and mating takes place.

The female larva.—This larva has greatly elongated and is now 1.25 to 1.50 mm. in length, including the anal setæ. The cephalothorax is somewhat oval in shape, being narrowed anteriorly, and its longitudinal and transverse diameters are in the proportion of 8 to 5. No new thorax segment has been added, but the genital segment has greatly increased in size, and there are now three abdominal segments instead of two.

The first antennæ remain four-jointed; the second pair have become longer, and the prehensile claw at their tips has increased greatly in size. Of the mouth parts the mandibles and first maxillæ can be made out much more easily than in the adult. The first four pairs of swimming legs have three-jointed rami, and each fifth leg now has a single distinct one-jointed ramus tipped with long setæ.

At the posterior corners of the genital segment is a single large seta on either side, marking the sixth legs. The fifth segment is fused with the genital segment, the separation being indicated by deep lateral notches behind the bases of the fifth legs.

In a little older larva there is a marked elongation of the thorax, the segments separating from one another so as to leave wide lateral notches. (See fig. 54, pl. XII.)

Female larvæ of another species in the fourth copepodid stage were obtained from the gills of the bullhead, *Ameiurus nebulosus*, from Drury Slew, July 23, 1915. In these the carapace and the free thorax segments were relatively shorter and wider (fig. 41–49, pl. XI); the fifth segment was distinctly separated from the genital segment, the latter being the wider of the two and nearly twice as wide as long; and the anal laminæ and setæ were also longer and narrower.

The fifth legs had a wider basal joint, armed with a stout spine on the outer margin, while the ramus was armed with three spines, two at the tip and one on the outer margin; no rudiments of the sixth legs were visible in dorsal view. In the maxillipeds the terminal joint was relatively shorter and narrower, and the basal joint was much less inflated through the center. It is impossible to locate this species with certainty, but it is at least highly improbable that it is a larval form of *tortua*, the adult female of which is sometimes found upon this same bullhead. It is also worthy of note that its host, the bullhead, is a fish which stays on or close to the bottom, while the short-nosed gar, the host of the *variabilis* larva stays close to the surface of the water.

The male larva.—This larva is similar to the female in most particulars, but shows some sex differences. The body in general is shorter and relatively wider, especially the cephalothorax, whose longitudinal and transverse diameters are in the proportion of 7 to 6. The free thorax segments are also wider and shorter than in the female (See fig. 36, 53, pl. X, XII.)

The only differences in the appendages are in an increase in the size and curvature of the prehensile claws on the second antennæ and the terminal claws on the maxillipeds, longer and stouter rami on the swimming legs, and in the size of the sixth legs.

Male larvæ of another species, probably *cruciata*, were obtained from the gills of the sauger. (See fig. 36, pl. X.) On these the cephalothorax is relatively longer and narrower, but the anterior margin is wider and projects some distance over the bases of the antennæ. The second (first free) thorax segment is as wide as the carapace, but the third, fourth, and fifth segments diminish very rapidly, the fifth being only one-third the width of the second. The genital segment is wider than the fifth segment, while the abdomen segments are considerably narrower.

The maxillipeds have a rather slender basal joint, with an enlargement on the inner margin just above the spine and close to the base of the terminal joint.

Total length of female, 1.25 to 1.50 mm.; of male, 1 to 1.15 mm. Carapace of female 0.32 mm. long, 0.20 mm. wide; of male 0.28 mm. long, 0.24 mm. wide. Anal laminæ and setæ 0.20 to 0.30 mm. long.

Color of both sexes like that of yellowish cartilage, the digestive tract black, the tripartite eye a bluish-purple.

THE INTERNAL STRUCTURE OF THE FOURTH COPEPODID LARVA.

Circulation.—The most conspicuous part of the internal mechanism (fig. 62–67, pl. XIII) of the living larva is the digestive tube, which runs straight through the center of the body. Its contents are jet black in color and reach back into the genital segment, the portion of the intestine behind that, together with the rectum, being transparent and colorless.

Every little while a small portion of this black material, which is the partly digested blood from the gills of the host, is separated from the rest, rolled up into a rounded mass, and passed back into the rectum, from which it is soon ejected.

The only circulation in the larva is produced by these movements of the digestive canal. The anterior end of the stomach is fastened to the dorsal wall of the head by three muscles, whose contraction draws the entire digestive tube forward. It is then drawn back again by muscles connected with the rectum and the posterior end of the intestine.

In addition to these forward and backward movements there is also a peristaltic wave of contraction, which starts at the anterior end of the stomach at the same time that the latter is drawn forward. This wave travels backward and reaches the rectum at about the time the forward movement of the whole digestive canal ceases. Accordingly when the backward movement of the canal begins the peristaltic contraction is reversed and passes forward again. The combination of these two kinds of movements produces corresponding impulses in the contents of the body cavity around the digestive tube. But this is evidently more of a pulsation than a circulation, the body fluid simply moving back and forth longitudinally and transversely, without crossing from one side to the other and with very little real mixing of the various portions. It may be noted here that this same backward and forward movement of the digestive tube persists in the mature female and constitutes her only method of respiration.

The digestive canal.—The mouth is comparatively large and opens into a long and narrow œsophagus (*oe*, fig. 62, pl. XIII) which extends back of the center of the cephalothorax, the sphincter muscle at the opening into the stomach being exceptionally large. The walls of the stomach are thick and the digestive cells (*dc*) project so far as to nearly close the lumen. In this larva there is no distinction between stomach and intestine or between intestine and rectum; it is all one tube tapering gradually backward. The walls of the œsophagus are composed of an inner layer of pavement epithelium and a very thin outer muscular layer. The latter is much thickened over the stomach and intestine, where it produces the peristaltic movements just described. In place of the pavement epithelium both stomach and intestine are lined with a glandular epithelium made up of digestive cells of varying lengths, all of which are filled with a digestive fluid containing small black granules, which are so numerous as to cause the black color of the entire canal.

The nervous system.—The supra-œsophageal ganglion is comparatively small and subtriangular in horizontal outline. (See fig. 64, pl. XIII.) From the dorsal surface of the blunt posterior angle a nerve extends backward to the reproductive organs and the digestive canal, and from the rounded anterior side other nerves go to the antennæ.

The infraganglion is by far the largest that has thus far been found in any larval or adult copepod, the nearest approach to it being the one in the adult Ergasilid. It is so wide where it joins the œsophagus as to cover nearly the whole length of the latter and it extends backward into the genital segment. It tapers rapidly at first, shows a large swelling opposite the bases of the maxillipeds, and then tapers very gradually through the first five and into the sixth thorax segment. No swellings are found in it opposite the bases of the successive pairs of swimming legs, although good-sized nerves are given off to these. It is pierced close to the œsophagus by stout muscles which run from the anterior end of the stomach to the ventral wall of the head. Both ganglia contain a thick outer layer of cells, while the interior is made up of fibers, and the two are distinctly differentiated throughout the entire length of the ganglion.

These copepodid larvæ thus possess relatively the largest and best developed nervous system amongst the parasitic copepods, which is retained by the male throughout the rest of his life. But in the subsequent exaggerated elongation of the thorax of the female after she has attached herself to her final host, this nervous system is pulled out as if it were ductile into longer and narrower parts, and the two ganglia are greatly reduced in size. The outer cellular layer almost entirely disappears, and the infraganglion can not be traced beyond the second thorax segment. It looks as if during the great increase in size of the female no more nerve material could be obtained, and so the nervous system of the 1-mm. copepodid larva had to be made over to supply the 10-mm. or 15-mm. female.

The reproductive organs.—The ovaries and testes are paired and are situated in the posterior part of the cephalothorax and the first one or two free segments. They are close to the dorsal body wall above the stomach, and from their anterior end the oviduct or sperm duct, as the sex may be, leads back above the stomach and intestine to the genital segment.

In the male each testis is spindle-shaped and flattened dorsoventrally; the posterior end is usually more pointed than the anterior and is attached to the dorsal body wall; from the anterior end the sperm ducts run back to the genital segment, where it is greatly enlarged and forms an ellipsoidal pouch in which the spermatophores are prepared. (See fig. 63, pl. XIII.)

The walls of the ducts are very thick and glandular, secreting the cement substance which forms the outer covering or wall of the spermatophores. These latter are cylindrical and oblong with rounded ends and occupy the whole side of the genital segment. (See fig. 63, pl. XIII.)

In a horizontal section (fig. 64, pl. XIII) one testis is seen to be behind the other, the anterior one occupying the cephalothorax and first free segment, the posterior one the first and second free segments, both of them between the stomach and intestine and the dorsal body wall. Each testis is swollen until it fills nearly the whole width of the body, and in it can be seen the whole spermatogenesis—the large, nucleated sperm mother cells (*sm*) filling the posterior half of the testis, followed by a zone of sperm daughter cells (*sa*), and these transforming into the sperms (*se*) in the anterior end of the testis and filling the lumen of the sperm duct. In a cross section through the third thorax segment (fig. 67, pl. XIII) the posterior testis is seen to be saddled upon the dorsal surface of the intestine, while the sperm ducts appear on either side opposite the center of the testis. Beneath the intestine and close to the ventral surface is the broad thick trunk of the infra-œsophageal ganglion.

In the female the ovaries are also spindle-shaped and flattened dorsoventrally. The posterior end is attached to the dorsal body wall, and from the anterior end the oviduct leads back to the vulvæ in the genital segment. The posterior portion of the oviduct has not yet become glandular but is like the anterior portion, and the whole duct is without convolutions. The spermatophores of the male are attached to the vulvæ and their contents are discharged into the oviducts. The sperms probably remain here during the subsequent growth of the female's body and the ripening of the eggs, and when the latter pass down the oviduct they are fertilized just before reaching the glandular portion where the cement substance forms the egg membranes.

There is no frontal gland in these larvæ, the space in the anterior portion of the head being occupied by the powerful muscles which operate the mouth parts.

ADDITIONAL DATA.

Fifty gars whose gills were infested with the copepodid larvæ of *Lernæa variabilis* were obtained from Patterson Lake, near Fairport, Iowa, August 15, 1915, and were placed in cages in one of the fish ponds.

Three or four of these were examined twice a week in order to determine if possible how long the larvæ remained and what became of the two sexes after fertilization. The author could only carry the examination up to September 1, but W. B. Gorham, one of the regular station staff, very kindly continued it through the month of September and up to October 4, sending the specimens found upon the gills to the author for examination. H. W. Clark also collected samples of plankton, which were sent similarly for examination. In this way it has been determined that:

1. These larvæ appear first about the latter part of June and may be found upon the gills of the short-nosed gar until the middle of October.

2. Each copepodid stage occupies from 10 to 14 days and apparently is accompanied by several molts.

3. Fertilization occurs during the fourth copepodid stage, as was proven by finding the two sexes fastened together upon the gills and by witnessing the union once or twice while handling the larvæ in watch glasses.

4. After fertilization the female apparently seeks out her final host at once, since nothing more is seen of her either on the gills or in the free-swimming plankton. The male, on the contrary, remains upon the gills of the temporary host, and specimens were found every time the gills were examined.

5. During the several copepodid stages and for some time subsequently the two sexes are found in about equal numbers. Then the proportion of females diminishes steadily and by the last of September only an occasional female is left, while the males are apparently undiminished.

6. Careful and repeated search of the plankton does not reveal any of these larvæ, and hence we can only conclude that the male does not become a free-swimmer for a second time, but remains upon the gills of the first host until his death.

SYSTEMATIC.

The genus *Lernæa* differs from the other Lernæan genera in the following particulars:

1. The body is formed by a lengthening of all the thoracic segments instead of only the fifth and sixth. This separates the swimming legs and leaves them distributed throughout the length of the body instead of being bunched closely together behind the head; moreover there are five pairs of legs instead of four or only three.

2. The first antennæ are on the anterior margin and the second antennæ are on the ventral surface of the head, instead of being dorsal, and while the second pair are uncinate they are not chelate. There are two pairs of maxillæ and a pair of well-developed maxillipeds, instead of a single pair of maxillæ.

3. The egg strings are relatively short and club-shaped or spindle-shaped instead of being long and filiform. The eggs are large and spherical and multiseriate instead of being flattened into thin disks arranged in a single series like a row of coins.

4. In the ovary egg filaments are formed, consisting of oocytes packed tightly together in a single row; these separate from one another at the entrance into the oviduct and each oocyte absorbs food and yolk and becomes an egg. In the oviducts the eggs remain spherical and are arranged loosely in one or two rows. In the other Lernæidæ there are no egg filaments, but the eggs are formed singly and are tightly packed together in a single row exactly like those in the external cases.

5. The copepodid larvæ have no frontal filament but attach themselves to their first or temporary host by means of the second antennæ and the maxillipeds. Hence there is no loss nor even any diminution of the power of locomotion during the copepodid stages. In the other Lernæidæ there is a large frontal filament, and while the larva is attached by it to its temporary host the swimming legs and some of the mouth parts degenerate and become immovable, but are restored to their former condition during the second free-swimming period.

It would seem at first as if these differences were enough to separate this genus from the other Lernæids and to make of it a distinct family, as was advocated by Brühl. But as we examine and compare more closely we find similar differences among the other genera, which naturally lead up to the ones here mentioned.

In other words, these are differences in degree rather than in kind, and hence would not warrant separation as a distinct family. Thus in *Peniculus* there is an elongation of all the thorax segments, with a consequent separation of the swimming legs, and what we find here is only the same thing carried a little further. Again, most of the Lernæan genera have four pairs of swimming legs, but there are some that have three pairs and others that have only two, so that there is no fixed and constant number, and the presence of five pairs only makes the series so much the more complete.

The copepodid larvæ of such genera as are known possess the same antennæ and mouth parts as those of the present genus. It is only in the subsequent metamorphosis of the female that some of them are lost, and it is evident that such a loss by one sex only could hardly constitute a family distinction. The differences in the external egg strings and in the internal ovary and oviducts are very real differences, but even in this particular the other genera are not alike. In some the egg tubes are coiled into a tight spiral, in others they are gathered into a loose mass, while in most of the genera they are straight, filiform, and much longer than the entire body. The lack of a frontal filament is duplicated among the Caligidæ, where the larvæ of the Caliginæ, the Pandarinæ, and the Cecropinæ possess such a filament, while it is lacking in the larvæ of the Euryphorinæ.

The life history ought to count for more than anything else when considering relationships, and in all its essential features the life history of the present genus corresponds with that of the other Lernæans.

The likenesses, therefore, are as numerous and of greater importance than the differences and warrant the retention of this genus *Lernæa* in the family of the Lernæidæ.

Genus LERNÆA Linnæus.

External generic characters of female.—Head a rounded knob projecting from the anterior margin of the cephalothorax and placed nearly at right angles to the body axis, with a deeply buried, three-parted eye near the center of the dorsal surface. One or two pairs of horns, simple or forked, on the lateral margins of the cephalothorax; sometimes an unpaired horn on the center of the dorsal margin; horns conical and soft; neck soft, slender, and cylindrical, twisted but not flexed, enlarging gradually into the body, which is also cylindrical; a pregenital prominence on the ventral surface in front of the vulvæ; on the dorsal surface a bluntly rounded abdomen, which terminates in a minute papilla on either side of the anus; egg strings elongate-conical or ovoid, eggs large and multiseriate. Two pairs of antennæ, second pair uncinate; a very short conical proboscis; mandibles claw-shaped and without teeth; two pairs of maxillæ; four pairs of biramose swimming legs attached to transverse chitin bars, indicating segmentation; a fifth pair of one-jointed stumps just in front of the vulvæ.

Internal generic characters of female.—Œsophagus short, nearly straight, and diagonal to the body axis; anterior stomach with lateral lobes extending into the bases of the horns and more or less convoluted; posterior stomach passing insensibly into the intestine, which is straight, the same diameter for its entire length, and is abruptly contracted at the base of the abdomen into a short rectum, which is suspended from the abdomen walls by muscle strands; ovaries paired, close to the dorsal surface and near the posterior end of the body; matured oviducts with two long posterior and two shorter anterior loops; eggs remaining spherical and never flattened anteroposteriorly; no separate cement glands, the thickened glandular walls of the posterior oviducts serving that purpose; no distinguishable semen receptacles.

External generic characters of male.—Not developed beyond the fourth copepodid stage, which must hence be regarded as the adult stage; cephalothorax made up of the head and first thorax segment fused; second, third, and fourth thorax segments free; fifth and genital segments more or less fused; abdomen made up of three segments of about the same size; anal laminæ large, each terminated with a very long and stout plumose seta, jointed near its base, and two or three small spines. Appendages similar to those of the female, except that the prehensile claws on the second antennæ and maxillipeds are larger, the rami of the swimming legs are longer and stouter, and there are the rudiments of a sixth pair at the posterior corners of the genital segment.

Internal generic characters of male.—Œsophagus long and nearly parallel with the body axis; stomach passing insensibly into the intestine and that into the rectum, the entire tube lined with digestive cells filled with black granules; supra-œsophageal ganglion comparatively small, infraganglion very large and stout and extending back into the genital segment; testes paired but not side by side, in the head and anterior thorax above the stomach and intestine, spindle-shaped, with the sperm ducts leading from the anterior end back to the large spermatophore receptacles in the genital segment.

Type of the genus, *Lernæa cyprinacea*, Linnæus, first species.

(Lernæa, Λέρνη, a lake and town near Argos where Hercules slew the hydra.)

KEY TO THE SPECIES.

1. Two cephalothoracic horns, a lateral pair..2.
1. Three cephalothoracic horns, two paired and lateral, one unpaired and dorsal..................3.
1. Four cephalothoracic horns, a dorsal and a ventral pair..5.
    2. Horns directed laterally at right angles to body axis; posterior body not much wider than neck; pregenital prominence inconspicuous (8.40 mm.)[a]. .*diceracephala* (Cunnington), 1914, p. 194.
    2. Horns diagonal to body axis, directed posterolaterally; posterior body suddenly enlarged to four times the diameter of neck; pregenital prominence large (8 mm.). *anomala*, new species, p. 194.

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[a] These figures in parentheses represent the average length of each species.

3. Lateral horns simple, dorsal one bifid at apex; pregenital prominence inconspicuous; abdomen short (10 mm.)........*dolabrodes*, new species, p. 194.
3. Lateral and dorsal horns all dichotomously branched........4.
3. Lateral horns three or four pronged; dorsal horn stout and bifid at apex; pregenital prominence large; body club-shaped; abdomen long and wide (7.50 mm.)......*pectoralis* (Kellicott), 1882, p. 195.
    4. Lateral horns once bifid, dorsal horn twice bifid; body spindle-shaped; pregenital prominence absent (8 mm.)........*lagenula* (Heller), 1865, p. 195.
    4. All three horns twice bifid; body club-shaped; pregenital prominence divided, its two lobes and the abdomen the same size (10 mm.)........*catostomi* (Krøyer), 1863, p. 195.
    4. Lateral horns twice bifid; dorsal horn simple or once bifid; body club-shaped; pregenital prominence simple and much smaller than abdomen (12 mm.)..*tortua* (Kellicott), 1882, p. 195.
5. Dorsal and ventral horns about the same size........6.
5. Ventral horns much smaller than the dorsal........9.
    6. Pregenital prominence simple and much shorter than abdomen........7.
    6. Pregenital prominence divided, its lobes nearly as long as the abdomen........8.
7. Abdomen short and plump; pregenital prominence forming a distinct heel; ventral horns bifid (5.75 mm.)........*phoxinacea* (Krøyer), 1863, p. 195.
7. Abdomen short and plump; pregenital prominence not forming distinct heel; dorsal horns bifid (13.50 mm.)........*esocina* (Burmeister), 1835, p. 195.
7. Abdomen long and stout; pregenital prominence forming distinct heel; all the horns simple (14 mm.)........*haplocephala* (Cunnington), 1914, p. 195.
    8. Pregenital prominence divided into three broadly rounded lobes; horns long, slender, and straight (13.50 mm.)........*pomotidis* (Krøyer), 1863, p. 196.
    8. Pregenital prominence twice bifid, forming four narrow lobes; horns short, plump, and curved (10 mm.)........*cruciata* (Le Sueur), 1824, p. 196.
9. Pregenital prominence divided into distinct lobes; dorsal horns simple and undivided........10.
9. Pregenital prominence simple or only slightly indented; dorsal horns distinctly forked........11.
    10. Abdomen a short and broad triangle; dorsal horns cylindrical and standing out laterally at right angles to body axis (9 mm.)........*tenuis* (Wilson), 1916, p. 196.
    10. Abdomen long and conical; dorsal horns flattened dorsoventrally and curved forward in front of head, parallel to body axis (11.50 mm.)........*variabilis* (Wilson), 1916, p. 196.
11. Abdomen short and inclined to body axis; egg cases broadly elliptical; ventral horns mere knobs (14 mm.)........*barnimii* (Hartmann), 1870, p. 196.
11. Abdomen short and inclined to body axis; egg cases narrow and elongate; ventral horns half the length of dorsal (22.50 mm.)........*cyprinacea* (Linnæus), 1758, p. 196.
11. Abdomen long and parallel with body axis; ventral horns very short and slender (10 mm) ....*temnocephala* (Cunnington), 1914, p. 196.

Remarks.—Dr. W. A. Cunnington recently (1914) issued a valuable little paper on "Parasitic Eucopepods from Tanganyika, Africa," in which he included a list of described species with synonyms and a key to all the known species (seven in number), including three new ones described in the paper. But he overlooked Hartmann's paper (1870) on *barnimii*, one of the best that has ever been published, and also Kellicott's two papers describing *tortua* and *pectoralis*. The key published by Cunnington is an excellent one and is made the basis of the one here presented. One or two facts in connection with it are worthy of comment. It is based entirely upon characters that can be seen with an ordinary hand lens, as such a key ought to be for convenience. Amongst these characters the horns, of course, take a prominent place, but too much specific value ought not to be placed upon either the number or the arrangement of the horns. Consequently all the other external characters, including the average length of the species, have been introduced into the key, and these should be given their full value.

Cunnington, in writing of his own key, said: "I am not responsible for the rather remarkable assertion that *L. catostomi* possesses three cephalic arms, which, of course, renders the head quite asymmetrical" (p. 823).

The author can not see how the possession of three horns is any more remarkable than the possession of two or four. And certainly a median, dorsal, unpaired horn no more destroys the symmetry of the head than does the nose or the mouth on a man's face compared with his two eyes or ears. Moreover, there are five species which have such a dorsal horn instead of one, as will be seen from the key.

An outline drawing of the head and horns of all the species except *pectoralis*[a] is here included for facility of comparison. (See pl. XV.)

The four with three horns (*pectoralis* is the fifth) are arranged with the dorsal horn uppermost; the others are arranged as seen from the dorsal surface, as they are usually represented in figures, except *anomala*, whose distortion compels a diagonal view from the anterior end.

Lernæa diceracephala (Cunnington), 1914.

Lernæocera diceracephala Cunnington, Proceedings Zoological Society of London, 1914, p. 824.

Found in Lake Tanganyika on the gill arches of a large *Clarias mossambicus*. Only one perfect specimen known.

Lernæa anomala, new species. (Pl. XIV, fig. 68–70, 73, 74.)

Host and record of specimens.—Two females, one badly mutilated, were taken by H. D. Lucas from the body of *Micropterus salmoides* caught in Black Creek, N. C. The better specimen has been given Catalogue no. 47756, U. S. National Museum, and becomes the type of the species.

Specific characters of female.—General body form quite bizarre. In consequence of a flexure just behind the second swimming legs the cephalothorax is turned ventrally at right angles to the body axis, making the head parallel with that axis. A single pair of forked horns are attached to the dorsal surface of the first and second thorax joints. They are slightly flattened dorsoventrally, but very plump, and extend backward with their tips projecting slightly behind the angle of the flexure; these tips are swollen into subspherical knobs. The neck behind the head gradually increases in diameter back to the third swimming legs; just beyond these it is rather abruptly contracted to one-third its former size for a short distance. This constricted portion probably represents the region in contact with the skin of the host, all the anterior portion being buried in the tissues of the fish while the posterior part hung free in the water. Behind the constriction the neck again widens, but not as much as before, back to the fourth swimming legs, where it is again slightly constricted. Immediately behind these legs the genital segment begins and is widened abruptly to three and a half times the diameter of the fourth segment, forming a spherical swelling, which then narrows to twice the diameter and extends backward as an abdomen of uniform thickness, as long as the fourth segment and bluntly rounded at the tip, where it ends in two minute anal laminæ, each tipped with a short nonplumose seta. On the ventral surface, behind the spherical swelling and in front of the vulvæ, is the pregenital prominence in the form of a sphere of the same diameter as the abdomen and projecting its entire length. In the angle between this sphere and the abdomen posteriorly are the vulvæ with the remains of a pair of emptied egg sacks attached to them.

Head ovoid, the base of the oval posterior and raised considerably above the dorsal surface; first antennæ four-jointed and moderately armed with setæ; second antennæ two-jointed, the terminal joint uncinate; second maxillæ of the usual pattern ending in two claws; maxillipeds with a swollen basal joint, armed on the inner edge with a short spine, and a much narrowed terminal joint bearing five long curved claws.

Total length, 8 mm. Cephalothorax in front of flexure, 1 mm. Neck from the flexure to the genital segment, 4.65 mm. Genital segment and abdomen, 2.80 mm. Diameter of neck at third legs, 0.50 mm. Diameter of genital segment, 1.20 mm.

Color (preserved material), a brownish gray, genital segment and abdomen, darker than the head and neck.

(*anomalus*, unusual, exceptional, alluding to the general form.)

Remarks.—There can be no doubt that this represents a new species, since it has not a single feature in common with other species and yet possesses every generic detail. Its unlikeness to other species is so pronounced that it may be a monstrosity, but even as such it is worthy of description and record.

Lernæa dolabrodes, new species. (Pl. XIV, fig. 71, 72, 75–78.)

Host and record of specimens.—Five females with egg strings were taken from *Lepomis pallidus* in Lake Pepin, Wis., by A. F. Shira, director of the U. S. Fisheries biological station, Fairport, Iowa, and were generously turned over to the author. The most perfect of these has been selected as a type female and has been given catalogue no. 47757, U. S. National Museum. The others become paratypes with catalogue no. 47758, U. S. National Museum.

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[a] No figures of this species have ever been published.

Specific characters of female.—Cephalothorax in line with the neck axis and sending out at right angles on either side a long tapering and unbranched horn and dorsally a single very short horn, slightly bifid at the tip. Neck of uniform width as far as the third pair of legs, then increasing gradually in diameter and passing insensibly into the trunk, which is widest at the posterior end, with a short bilobed prominence over the base of each egg string. Between these on the ventral surface is the pregenital prominence, which is about half the length of the abdomen and the same width. On the dorsal surface is the abdomen, tapered considerably but bluntly rounded and tipped with the two tiny anal laminæ, each carrying a short terminal seta. Egg strings half the diameter of the genital segment and two-fifths the entire body length, cylindrical, and about the same diameter throughout; eggs not arranged in rows, about 200 in each string.

Head small, nearly circular in outline, and projecting only a little; first antennæ four-jointed, basal joint the shortest and stoutest, second joint the longest; first three joints with a heavy fringe of setæ along their anterior margins, third joint giving off at the distal end a very large and long seta, fourth joint short and narrow with a terminal tuft of setæ. Second antennæ two-jointed, basal joint about half the length of the terminal, the latter tipped with a stout claw and a tuft of large setæ. Maxillæ projecting well beyond the tip of the mouth tube, their terminal claws large and sharply-pointed. Maxillipeds tipped with five rather short and slender claws, basal joint with a prominent knob at the inner distal corner and a smaller knob, tipped with a spine, on the inner margin. The swimming legs are of the usual pattern, the most essential difference being in their respective locations as seen in the table on page 176.

Total length, 10 mm. Transverse length of two arms and head, 6 mm. Diameter of neck, 0.33 mm. Greatest diameter of trunk, 1 mm. Length of egg strings, 4 mm.

Color (preserved material), a uniform grayish-white.

(*dolabrodes*, *dolabra*, a pickax and εἰδος, similarity.)

This species is easily recognized by its pickax form and by the short dorsal horn. These observations can then be supplemented by the position of the swimming legs and other details.

Lernæa pectoralis (Kellicott), 1882.

Lernæocera pectoralis, Kellicott, Proceedings American Society, Microscopists, vol. 4, p. 77.

Host and record of specimens.—Found in the axilla of the redfin shiner, *Notropis cornutus*, from the Shiawasee River, Mich.

Lernæa lagenula (Heller), 1865.

Lernæocera Lagenula, Heller, Reise der Fregatta Novara, p. 246; pl. 24, fig. 9.

Host and record of specimens.—Found upon an undetermined fish from Brazil.

Lernæa catostomi (Krφyer), 1863.

Lernæocera catostomi, Krφyer, Bidrag til Kundskab om Snyltekrebsene, p. 321; pl. 18, fig. 4, a–e.

Host and record of specimens.—Taken by Krφyer from the large-scaled sucker, *Moxostoma macrolepidotum*, caught in the Mississippi River near St. Louis, Mo.

Lernæa tortua (Kellicott), 1881.

Lernæocera tortua, Kellicott, Proceedings American Society, Microscopists, vol. 2, p. 41, 1 unnumbered pl.

Host and record of specimens.—Found in tumors upon the external surface of the bullhead, *Ameiurus nebulosus*, in Grindstone Creek near Lake Ontario. Subsequently found upon the hog sucker, *Catostomus nigricans.*

Lernæa phoxinacea (Krφyer), 1863.

Lernæocera phoxinacea, Krφyer, Bidrag til Kundskab om Snyltekrebsene, p. 325; pl. 18, fig. 3, a–d.

Host and record of specimens.—A single specimen was taken from the European minnow, *Phoxinus marsilii*, obtained from the Vienna Museum.

Lernæa esocina (Burmeister), 1835.

Lernæocera esocina, Burmeister, Acta Acad. Caes. Leop. Carol. Nat. Cur., vol. 17, p. 312. Nordmann, Mikrographische Beiträge, 1832, part 2, p. 123; pl. 6, figs. 1 to 6.

Host and record of specimens.—Found upon various species of European perch, carp, roach, pike, stickleback, burbot, etc.

Lernæa haplocephala (Cunnington), 1914.

Lernæocera haplocephala, Cunnington, Proceedings Zoological Society of London, 1914, p. 826; pl. 1, fig. 4–7.

Host and record of specimens.—Taken from different species of the ganoid genus *Polypterus* in Lake Tanganyika and the White Nile.

Lernæa pomotidis (Krøyer), 1863.

Lernæocera pomotidis, Krøyer, Bidrag til Kundskab om Snyltekrebsene, p. 323; pl. 15, fig. 5, a–h.

Host and record of specimens.—Found originally by Kroyer upon the bluegill, *Lepomis pallidus*, near New Orleans, La. Subsequently found on the same host at other places in the Mississippi River, and the copepodid larvæ upon the bullhead, *Ameiurus nebulosus*.

Lernæa cruciata (Le Sueur), 1824.

Lernæocera cruciata, Le Sueur, Jour. Acad. Nat. Sci. Philadelphia, vol. 3, p. 286; pl. 11, fig. 4.

Host and record of specimens.—Found originally upon the rock bass. *Ambloplites rupestris*, in Lake Erie. Subsequently found upon the sunfish, *Eupomotis gibbosus*, upon the largemouth black bass, *Micropterus salmoides*, upon the large-scaled sucker, *Moxostoma macrolepidotum*, and the copepodid larvæ upon the sauger, *Stizostedion canadense*.

Lernæa tenuis (Wilson), 1916.

Lernæocera tenuis, Wilson, Bulletin, U. S. Bureau of Fisheries, vol. XXXIV, p. 366.

Host and record of specimens.—Found upon the sheepshead, *Aplodinotus grunniens*, at Fairport, Iowa.

Lernæa variabilis (Wilson), 1916.

Lernæocera variabilis, Wilson, Bulletin, U. S. Bureau of Fisheries, vol. XXXIV, p. 365.

Host and record of specimens.—Found upon the bluegill, *Lepomis pallidus*, in the Mississippi River near Fairport, Iowa, and the copepodid larvæ upon the gills of the short-nosed gar, *Lepisosteus platostomus*.

Lernæa barnimii (Hartmann), 1870.

Lernæocera barnimii, Hartmann, Archiv fur Anatomie und Physiologie, 1870, p. 726; pl. 17, 18.

Host and record of specimens.—Found upon *Labeo nitoticus*, a fish of the River Nile.

Lernæa cyprinacea Linnæus, 1758.

Lernæa cyprinacea, Linnæus, Systema Naturæ, 10th ed., p. 655, pl. 2, fig. 1. Burmeister, Beschreibung einiger Schmarotzerkrebse, 1833, p. 309; pl. 24, A, figs. 1–3.

Host and record of specimens.—Found upon the European carp and pike.

Lernæa temnocephala (Cunnington), 1914.

Lernæocera temnocephala, Cunnington, Proceedings, Zoological Society of London, 1914, p. 827; pl. 1, fig. 8, 9.

Host and record of specimens.—Found upon *Barbus bynni* caught in the River Nile.

EXPLANATION OF PLATES.

PLATE VI.

Anatomy.

FIG. 1. Median longitudinal section of head and anterior thorax of *L. cruciata: c*, cephalon; *œ*, œsophagus; *s*, stomach. FIG. 2. Eye of *L. variabilis*. FIG. 3. Dorsal view of head, and anterior thorax of *L. variabilis*. FIG. 4. Head and neck of *L. tortua* from Black Creek, N. C., showing three complete revolutions. FIG. 5. Cephalon and mouth parts of *L. cruciata: an′* and *an″*, first and second antennæ; *c*, cephalon; *lb*, labium; *mx′* and *mx″*, first and second maxillæ; *mxp*, maxillipeds; *r*, rostrum. FIG. 6. Anal lamina of *L. cruciata*.

PLATE VII.

Internal morphology.

FIG. 7. Median longitudinal section of head of *L. cruciata: ig*, infraganglion; *m*, muscles; *oe*, œsophagus; *s*, stomach; *sg*, supraganglion. FIG. 8. Section of skin: *hy*, hypodermis; *il*, inner layer; *ol*, outer layer; *pc*, pore canal. FIG. 9. Head and anterior thorax of *L. variabilis*, showing *e*, the eye, and *s*, the convolutions of the stomach. FIG. 10. Young female of *L. variabilis*, ventral view, showing l^4 and l^5, fourth and fifth swimming legs; *ov* and *od*, ovary and oviduct; *rc*, rectum. FIG. 11. Fully grown female of same species, side view, lettering as before, and *cg*, cement gland. Fig. 12. Median longitudinal section of posterior body of *L. cruciata*, lettering as in fig. 11. FIG. 13. Section through pregenital prominence of *L. cruciata*, showing inner layer divided into separate cells, lettering as in fig. 8.

PLATE VIII.

Internal morphology.

FIG. 14. Reproductive organs of adult female of *L. cruciata*, lettering as in fig. 11. Fig. 15. Posterior end of ovary enlarged, showing genital protoplasm (*gp*) and egg filaments (*ef*). FIG. 16. Anterior end of same ovary, showing much enlarged egg filaments (*ef*) and the mature eggs (*e*) resulting from them. FIG. 17. Section of cement gland of *L. variabilis*, showing an egg (*e*) just ready to enter the glandular portion of the oviduct, and gland cells (*gc*). FIG. 18. Transverse section of the glandular portion of another specimen. FIG. 19. Transverse section through the body of *L. cruciata*, posterior to the ovaries: *cg*, cement gland; *od*, oviduct containing eggs; *i*, intestine. FIG. 20. Section of a fully formed blastula, showing superficial cleavage.

PLATE IX.

The nauplius and second and third copepodid larvæ.

FIG. 21. Second copepodid larva from gills of *Lepisosteus platostomus*. FIG. 22. Newly hatched nauplius, after Nordmann. FIG. 23. Third copepodid larva from gills of *Stizostedion canadense*. FIG. 24. Mouth parts, ventral view, lettering as in fig. 5. FIG. 25–29. First, second, third, fourth, and fifth swimming legs. FIG. 30. Maxilliped.

PLATE X.

Copepodid larvæ.

FIG. 31. First copepodid larva from gills of *Lepisosteus platostomus*. FIG. 32. First antenna. FIG. 33. Second antenna. FIG. 34, 35. First and second swimming legs. FIG. 36, 37. Male and female fourth copepodid larvæ from gills of *Stizostedion canadense*. FIG. 38. Ventral view of maxillæ. FIG. 39. Dorsal view of maxilla. FIG. 40. Maxilliped.

PLATE XI.

Copepodid larvæ.

FIG. 41. Female fourth copepodid larva from gills of *Ameiurus nebulosus*. FIG. 42. First antenna. FIG. 43. Second antenna. FIG. 44. Maxilliped. FIG. 45–49. First, second, third, fourth, and fifth swimming legs. FIG. 50. Mandible of fourth copepodid larva from gills of *Lepisosteus platostomus*. FIG. 51. First (upper) and second (lower) maxillæ. FIG. 52. Maxilliped.

PLATE XII.

Copepodid larvæ.

FIG. 53, 54. Male and female fourth copepodid larvæ taken together from gills of *Lepisosteus platostomus*. FIG. 55. Second antenna. FIG. 56. Dorsal view of mouth parts separated from mouth tube. FIG. 57–61. First, second, third, fourth, and fifth swimming legs.

PLATE XIII.

Internal anatomy of fourth copepodid larvæ.

FIG. 62. Median longitudinal vertical section. FIG. 63. Vertical section of posterior body a little to one side to show spermatophore receptacle. FIG. 64. Horizontal longitudinal section. FIG. 65. Longitudinal diagonal section, showing eye. FIG. 66. Section of sperm duct, enlarged. FIG. 67. Transverse section of body through the testes. Lettering; *dc*, digestive cells; *e*, eye; *i*, intestine; *ig*, infraganglion; *m*, muscles; *oe*, œsophagus; *sa*, sperm daughter cells; *sd*, sperm duct; *se*, sperms; *sg*, supraganglion; *sm*, sperm mother cells; *sp*, spermatophore; *sr*, spermatophore receptacle; *s*, stomach; *r*, rectum; *t*, testis.

PLATE XIV.

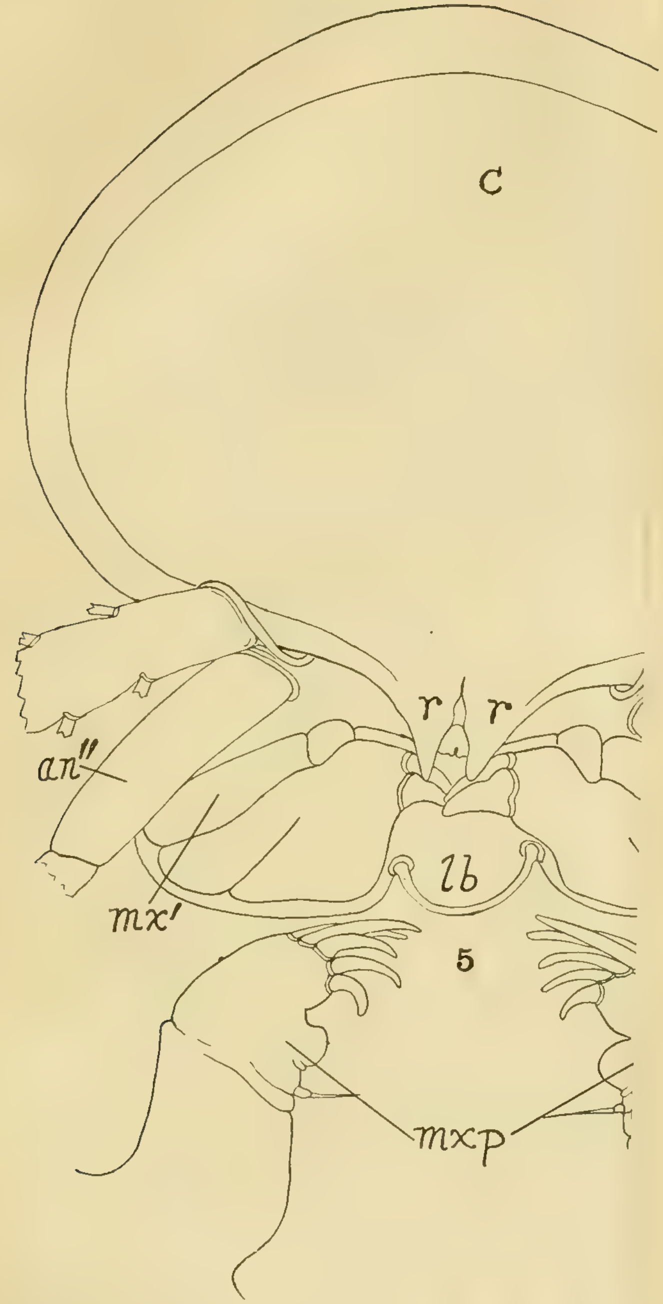
Lernæocera anomala and L. dolabrodes, new species.

FIG. 68. *L. anomala*, side view. FIG. 69. Ventral view of same. FIG. 70. Cephalon, antennæ, and mouth parts. FIG. 71. First antenna of *L. dolabrodes*. FIG. 72. Second antenna. FIG. 73. First swimming legs of *L. anomala*. Fig. 74. Second antenna of same. FIG. 75. *L. dolabrodes*. FIG. 76. Mouth parts. FIG. 77, 78. First and second swimming legs.

PLATE XV.

Head outlines of the different species.

FIG. 79. *dolabrodes*. FIG. 80. *tortua*. FIG. 81. *lagenula*. FIG. 82. *catostomi*. FIG. 83. *anomala*. FIG. 84. *cruciata*. FIG. 85. *esocina*. FIG. 86. *cyprinacea*. FIG. 87. *temnocephala*. FIG. 88. *phoxinacæ*. FIG. 89. *tenuis*. FIG. 90. *diceracephala*. FIG. 91. *variabilis*. FIG. 92. *haplocephala*. FIG. 93. *pomotidis*. FIG. 94. *barnimii*.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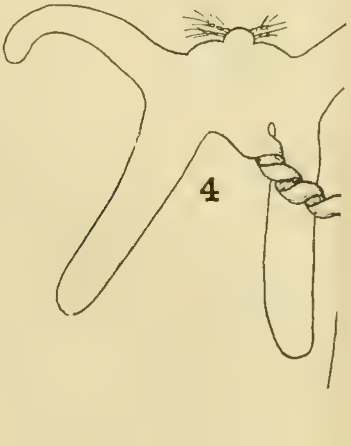

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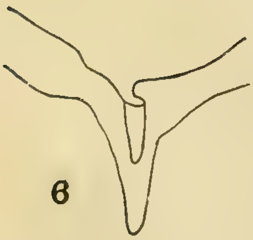

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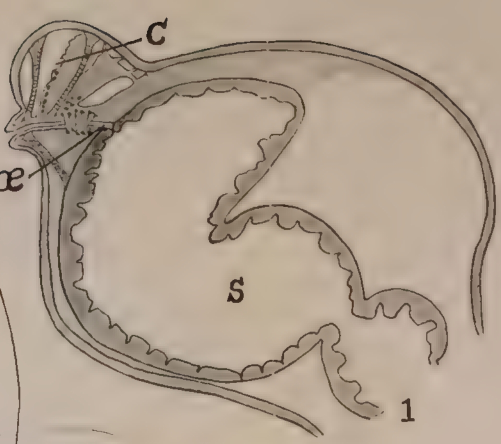

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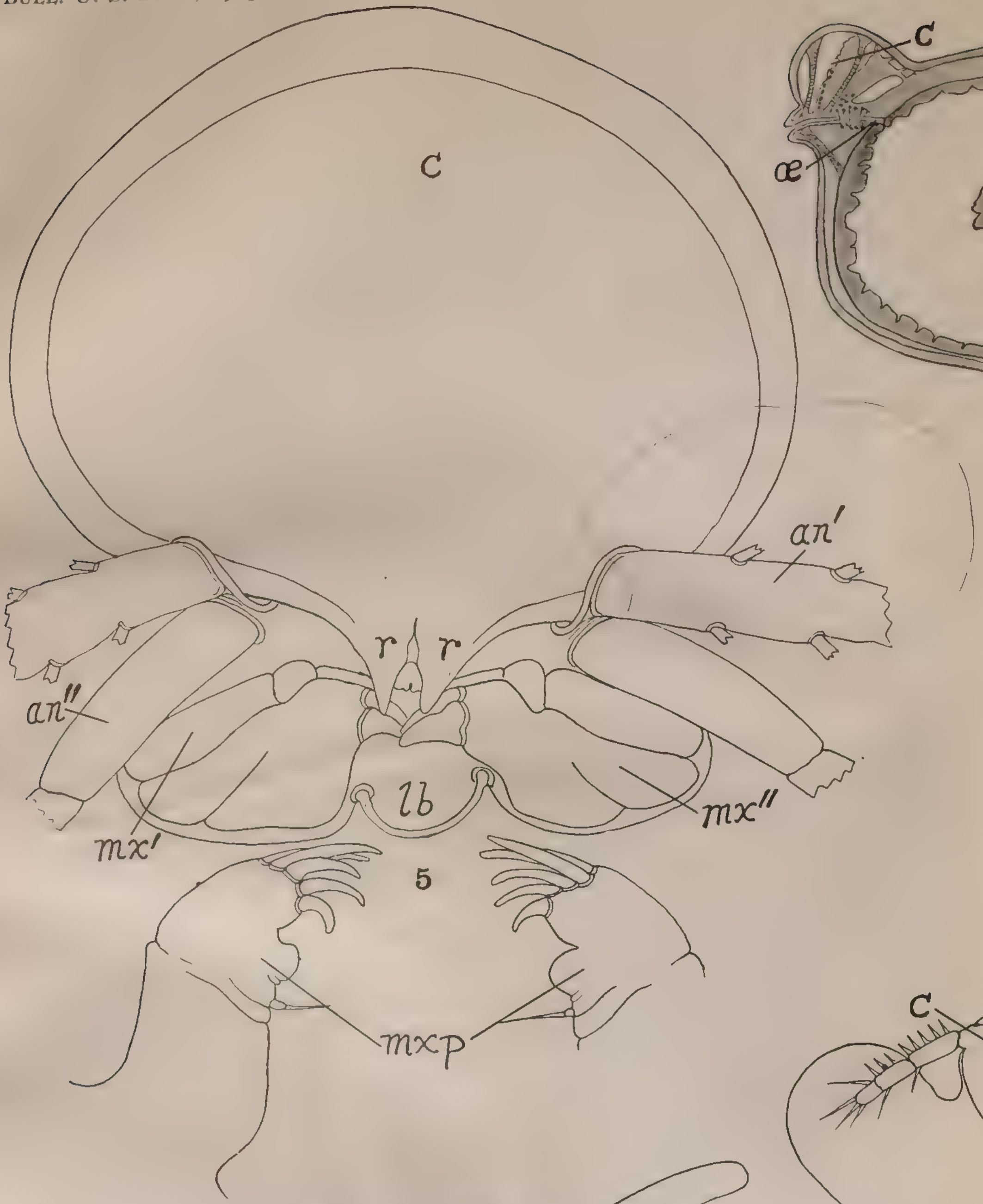
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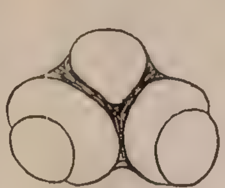

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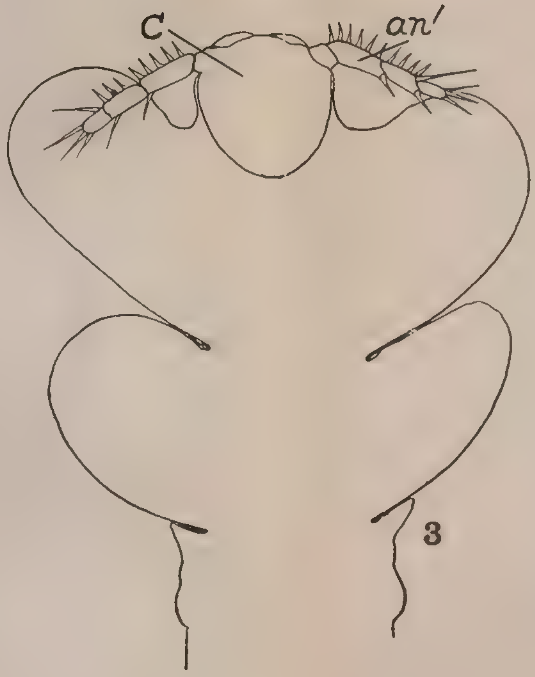

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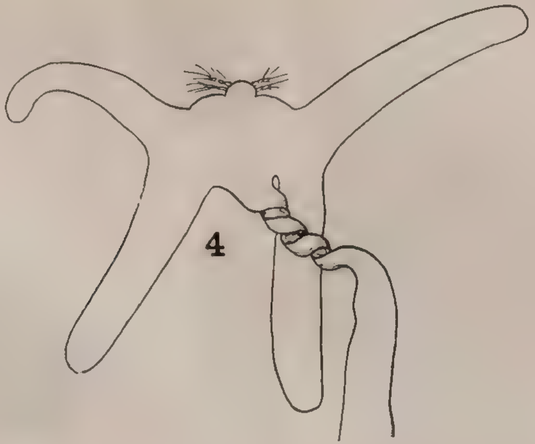

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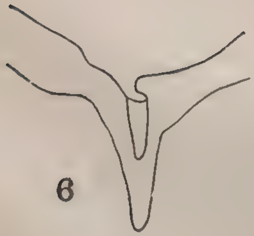

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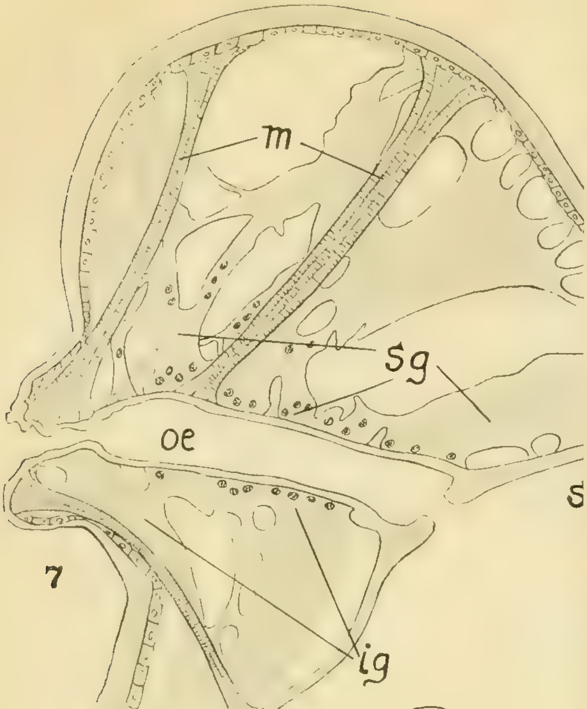
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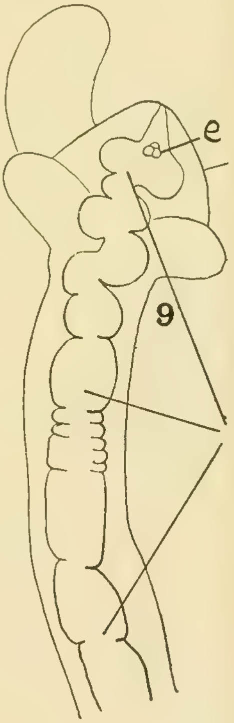

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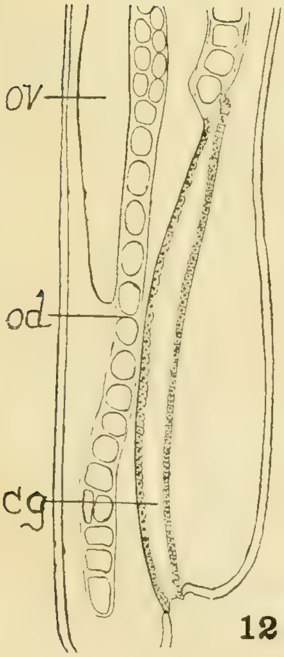

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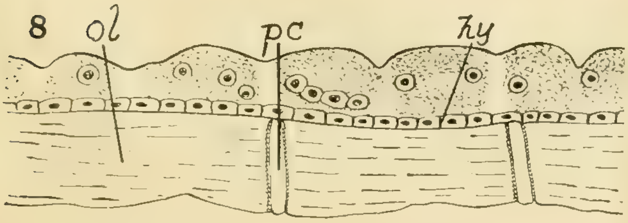

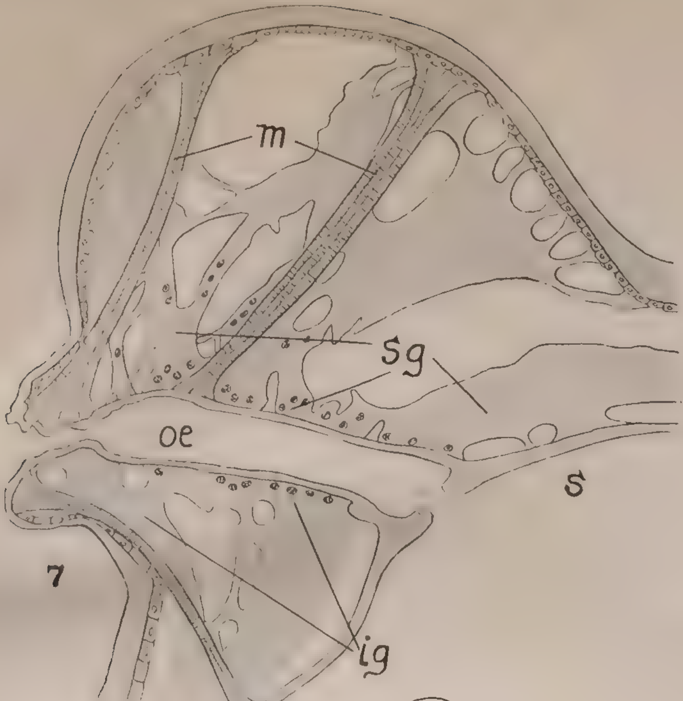

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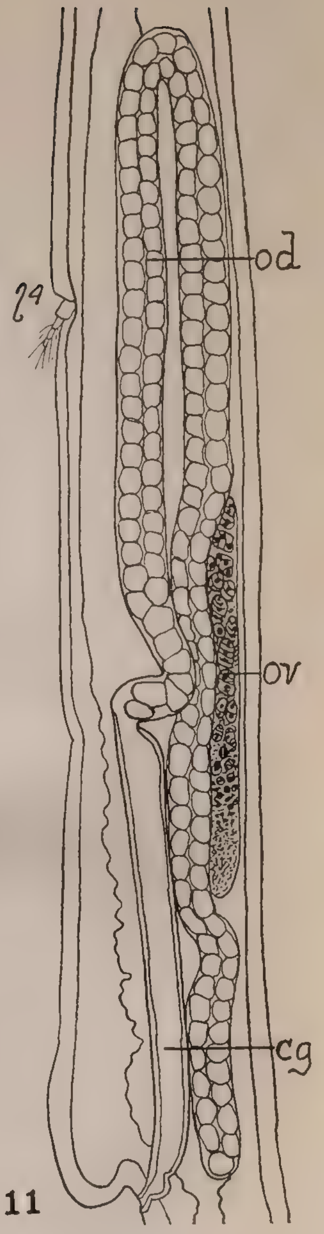

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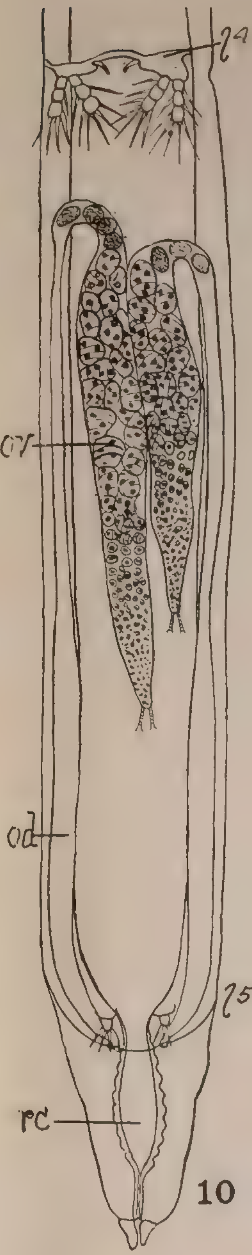
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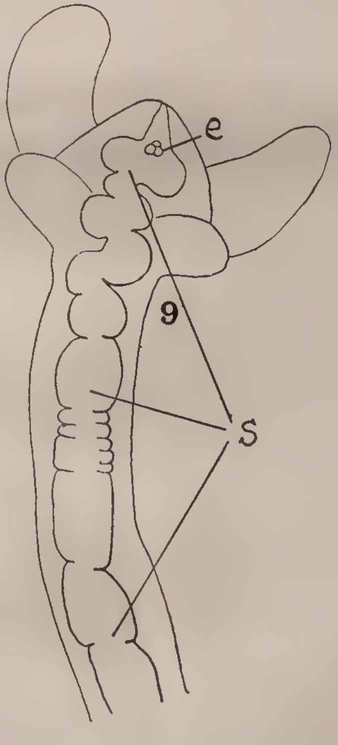

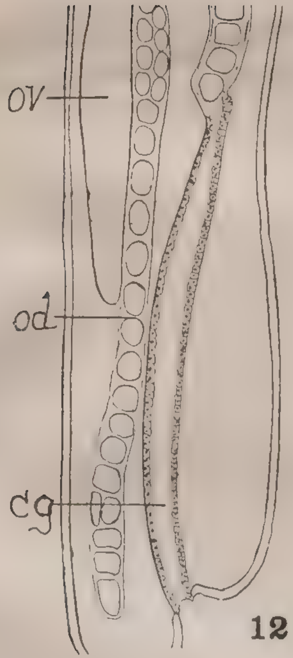

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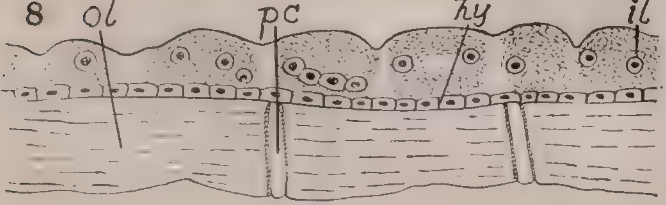

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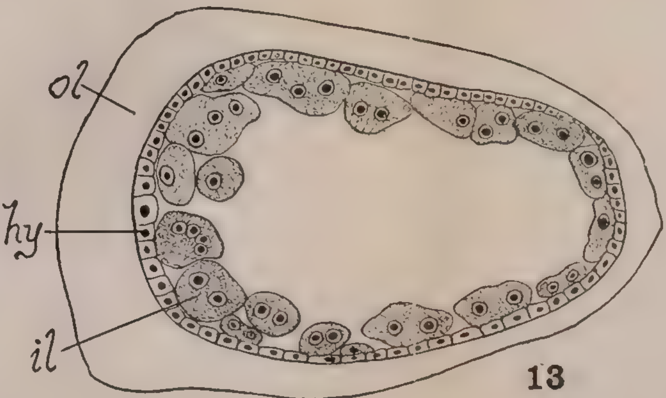

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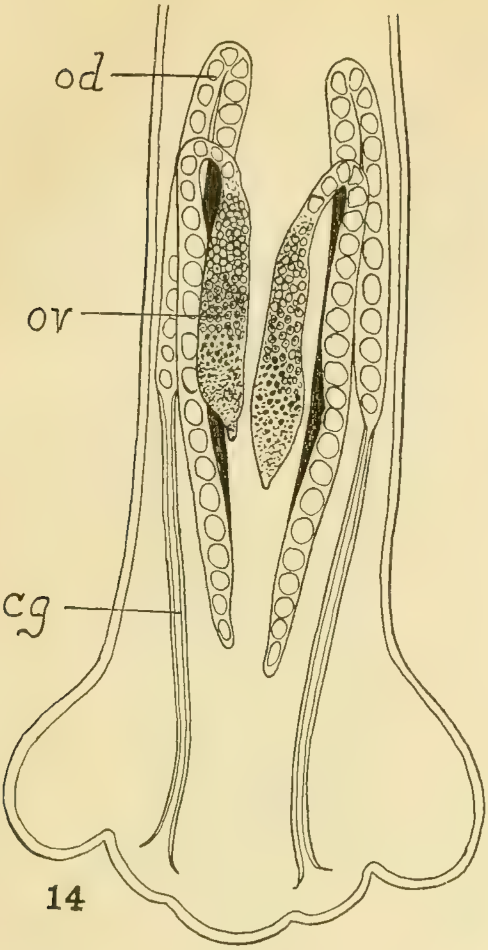

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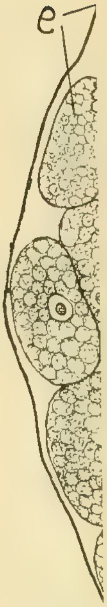

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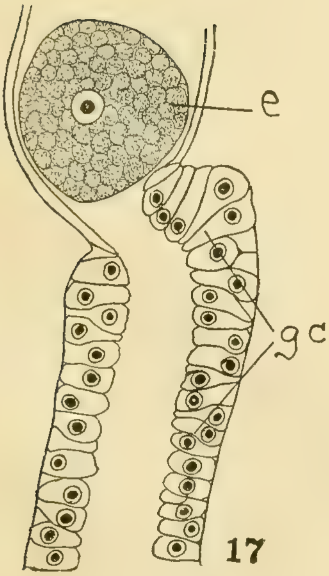

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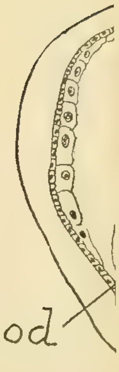

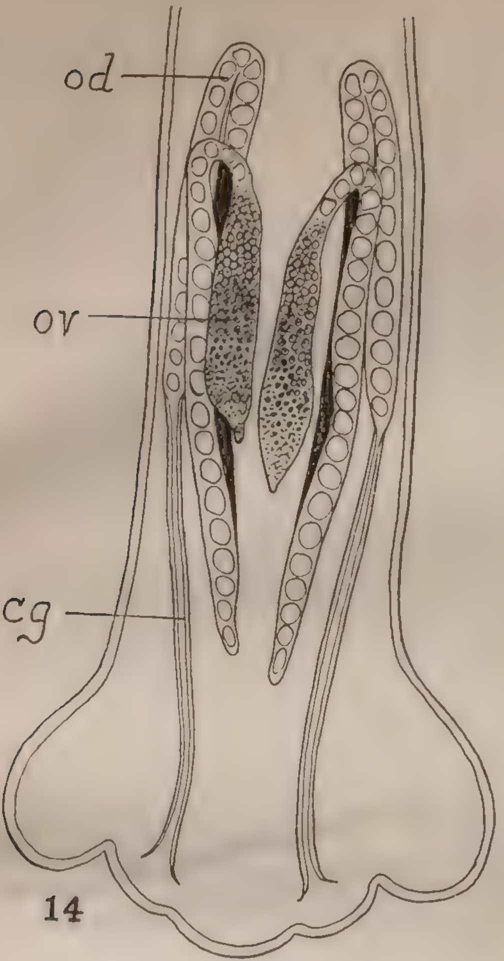

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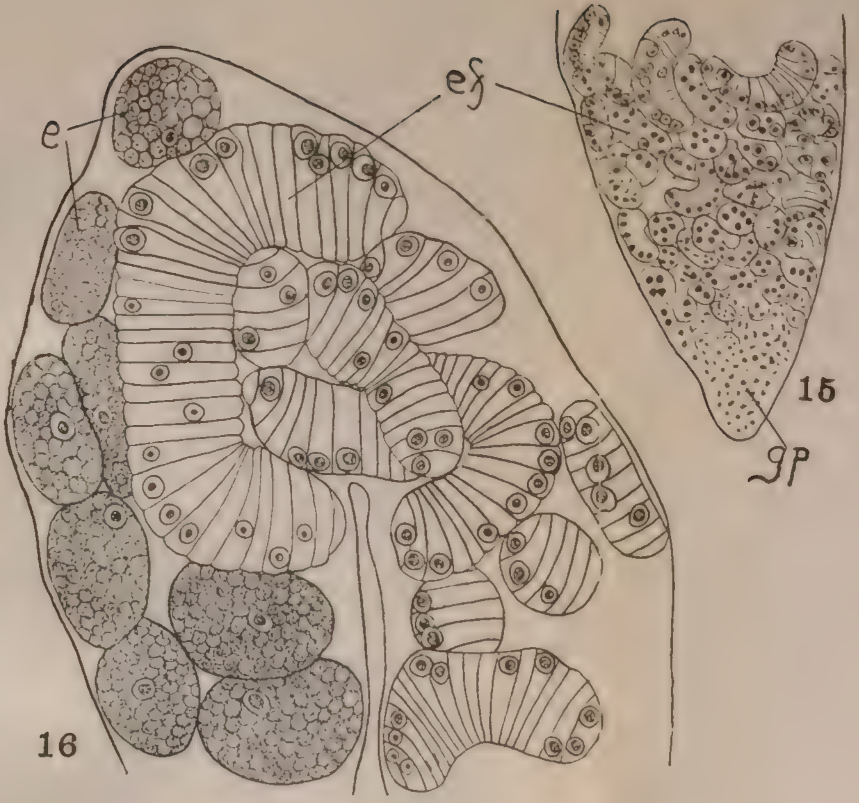

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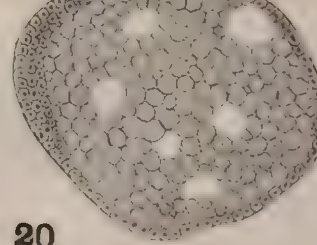

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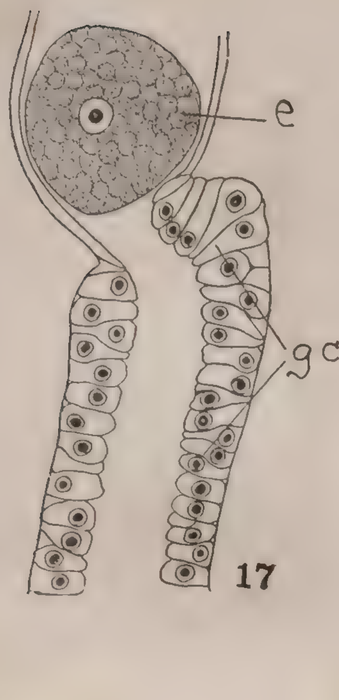

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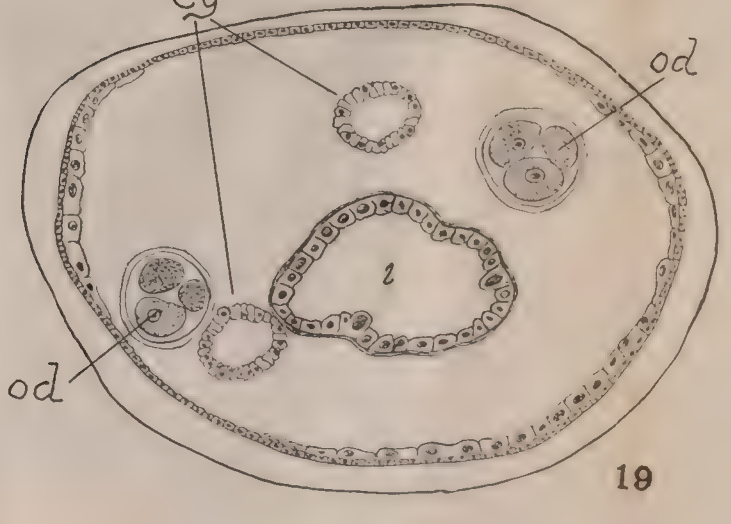

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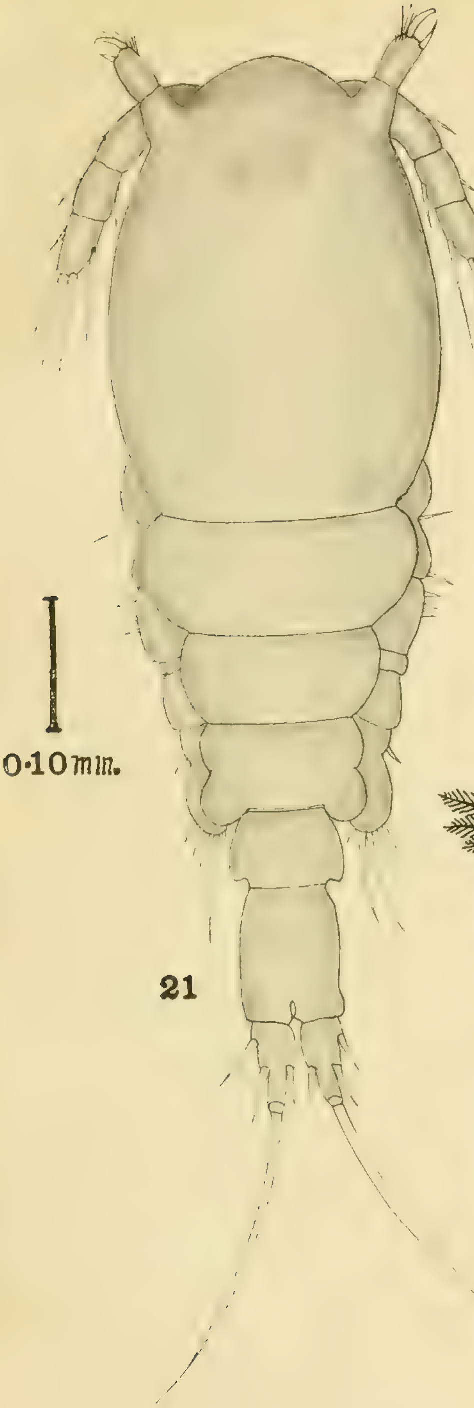

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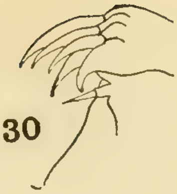
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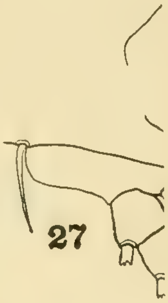
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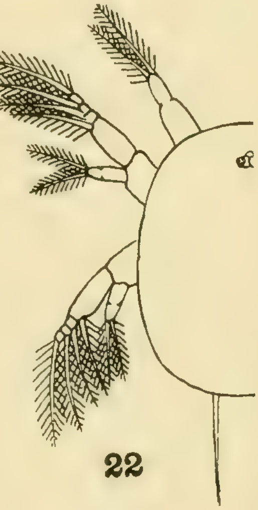
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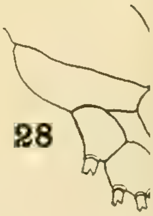
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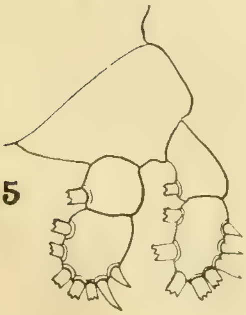
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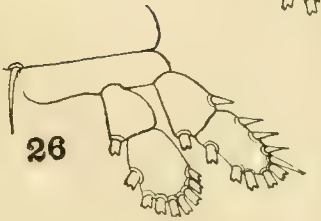
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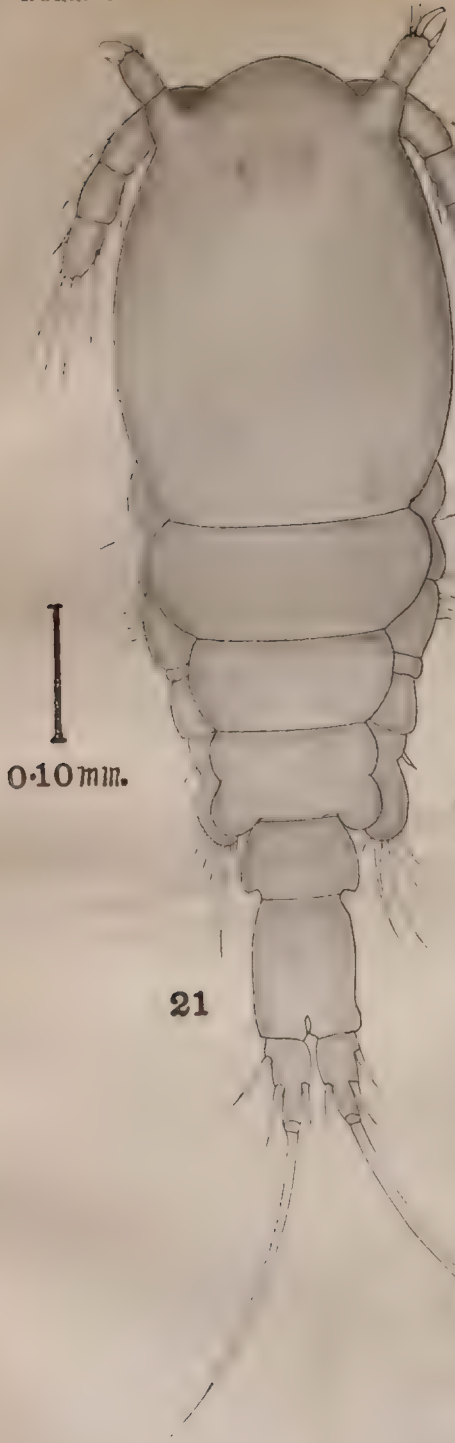

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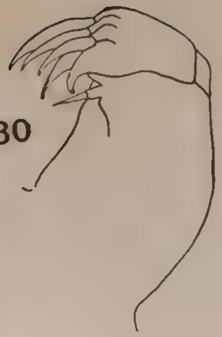

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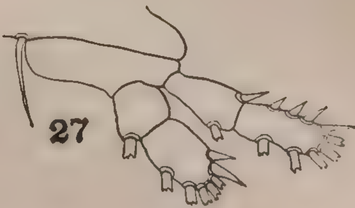

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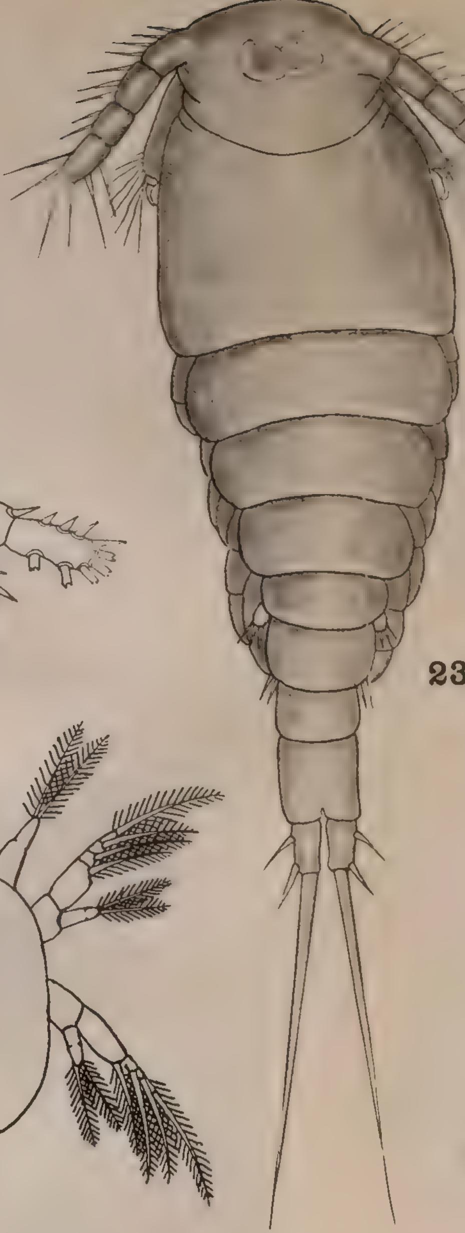

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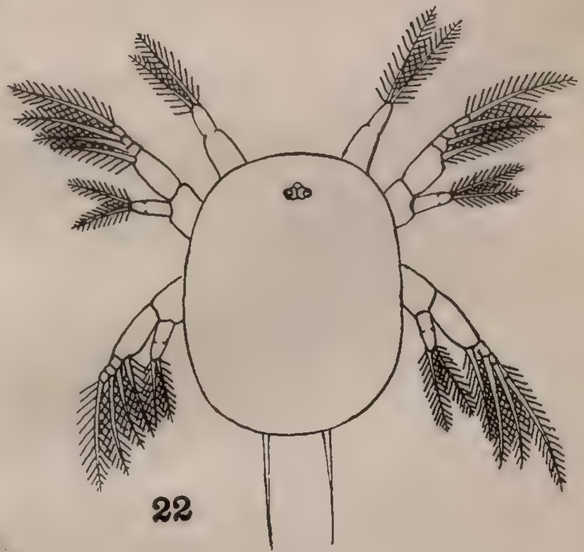

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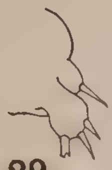

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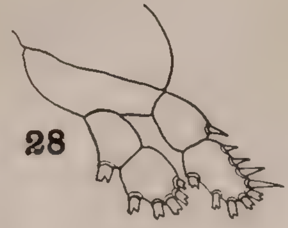

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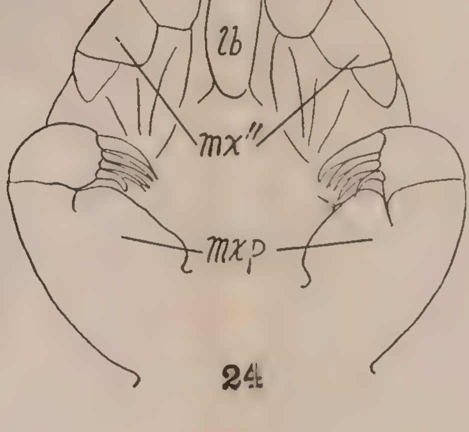

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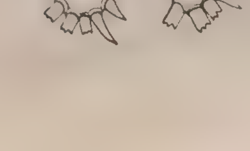

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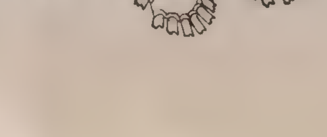

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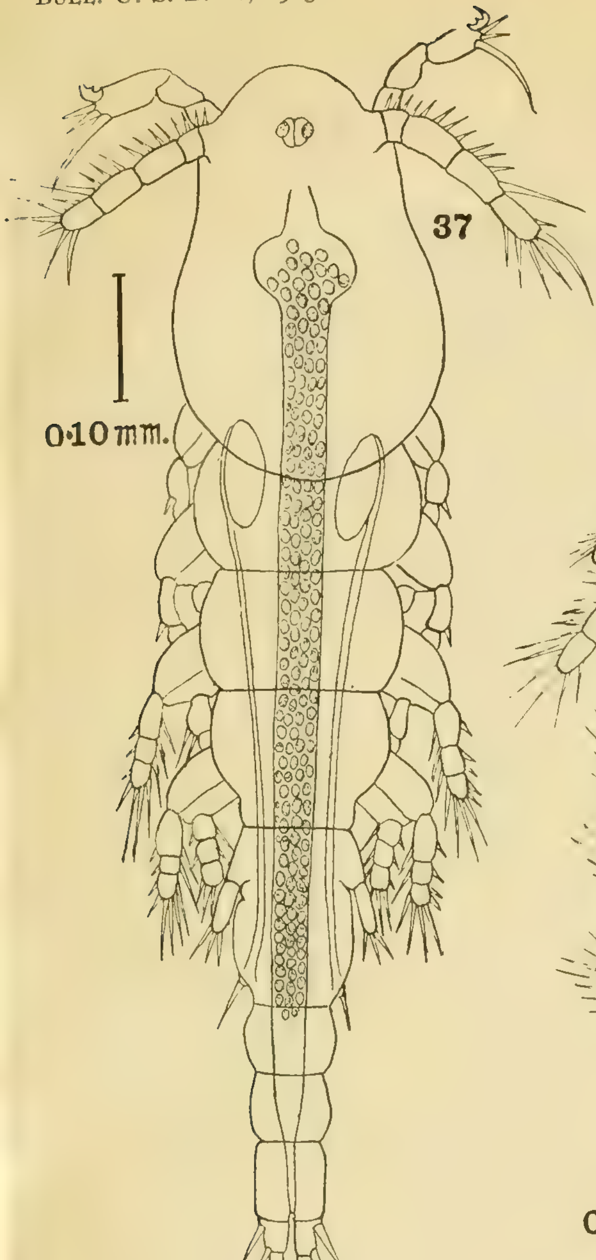

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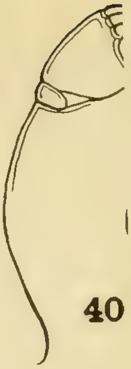

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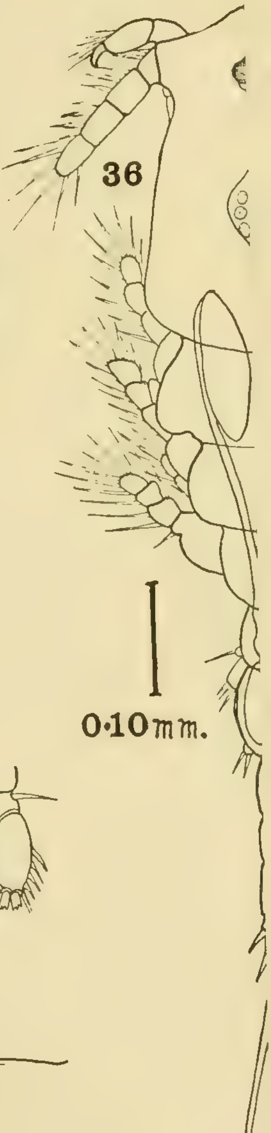

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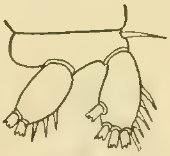

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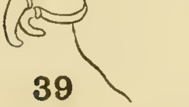

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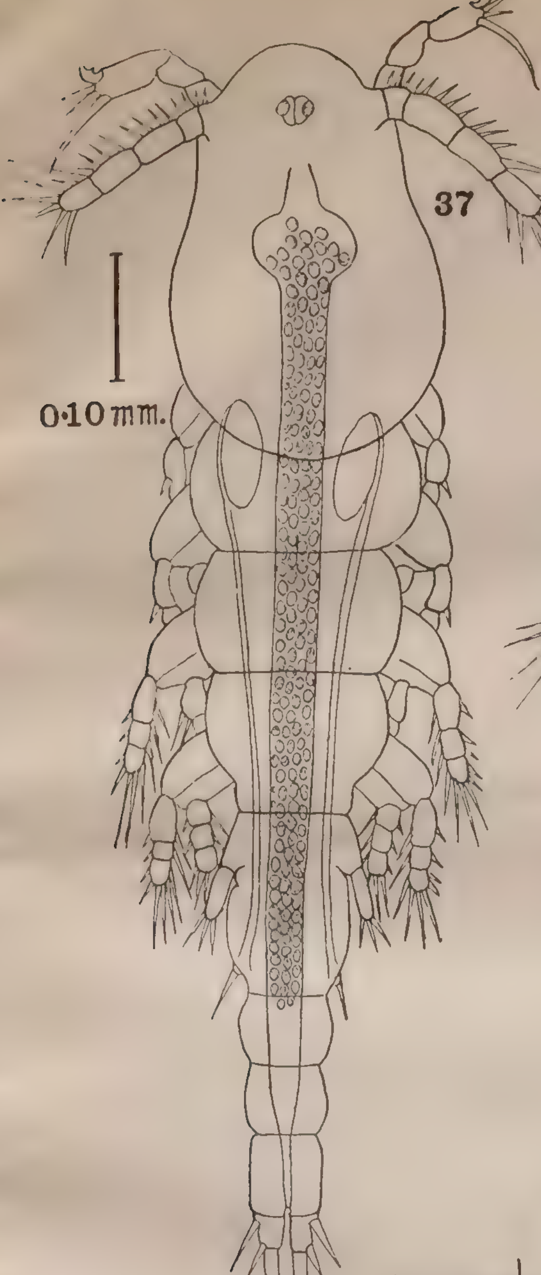
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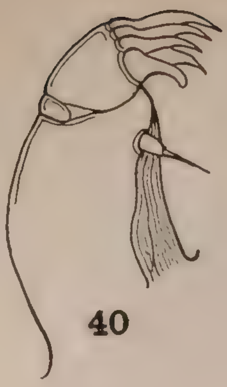
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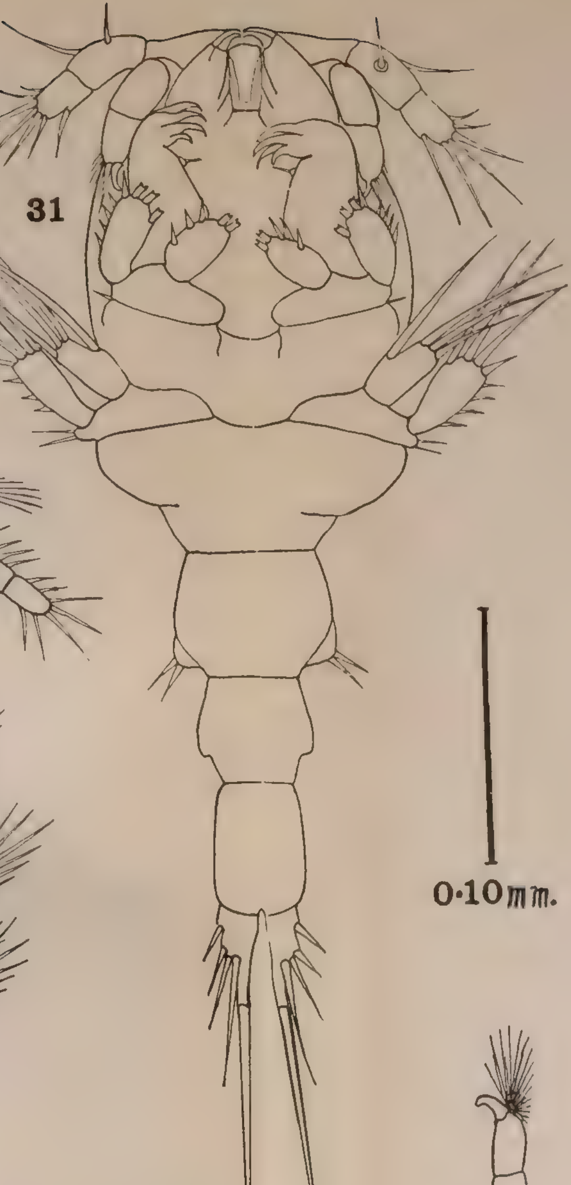
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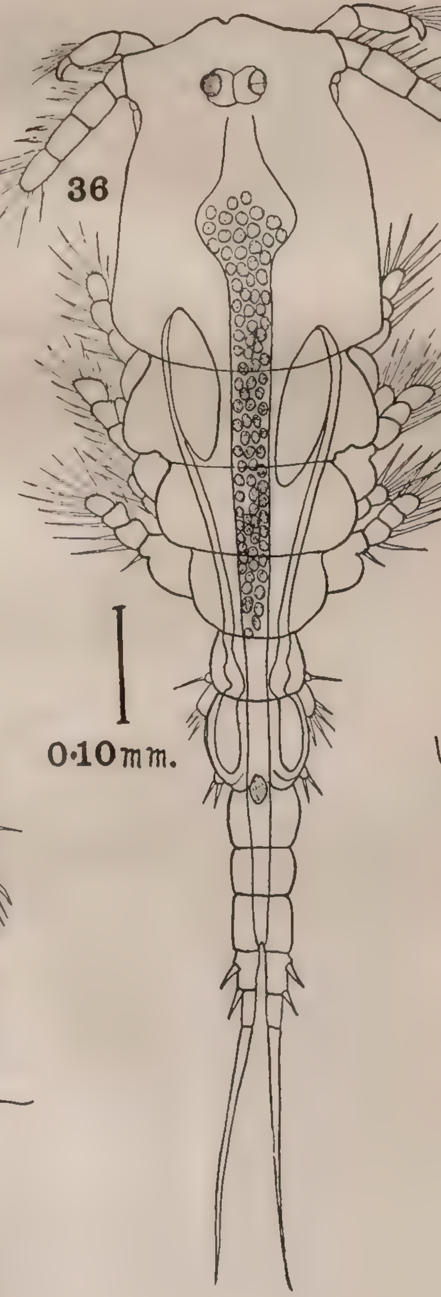
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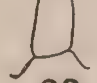
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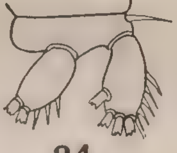
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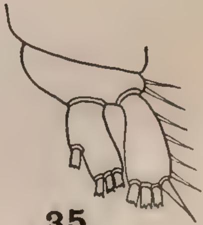
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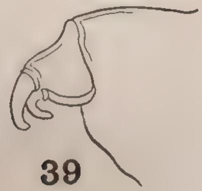
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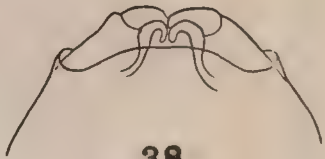
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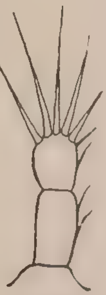
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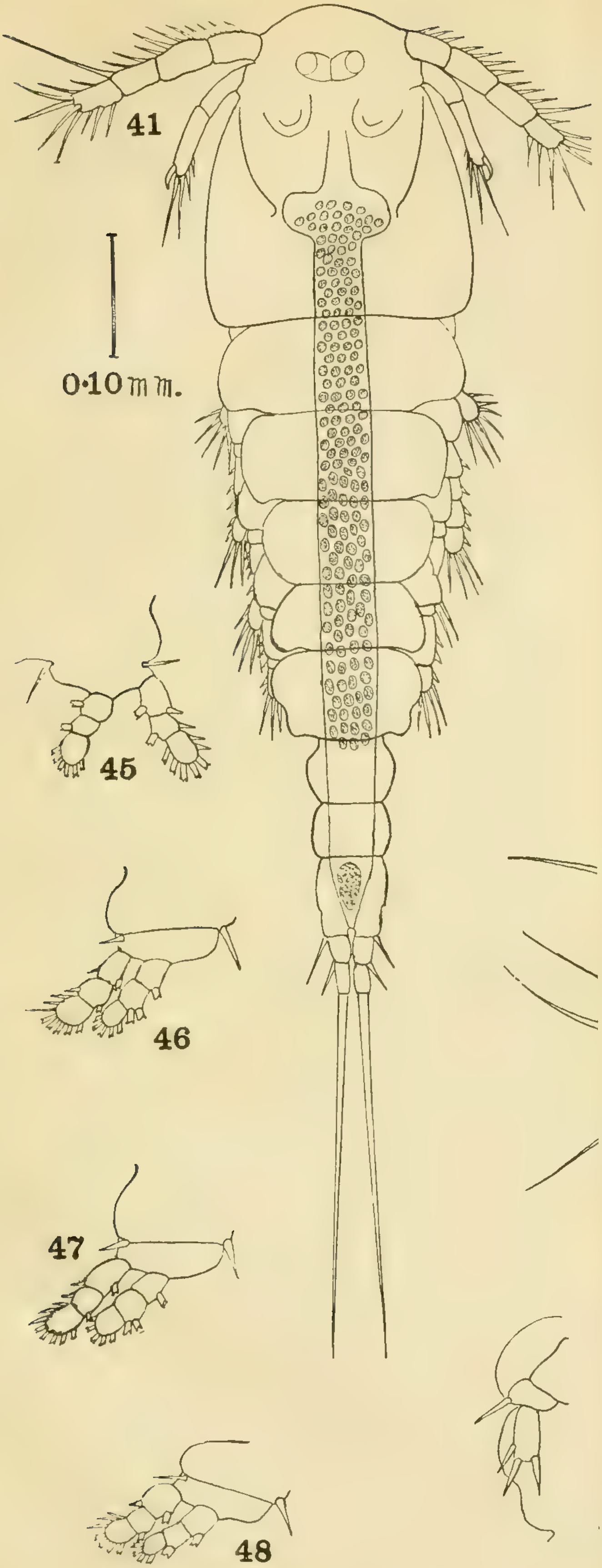

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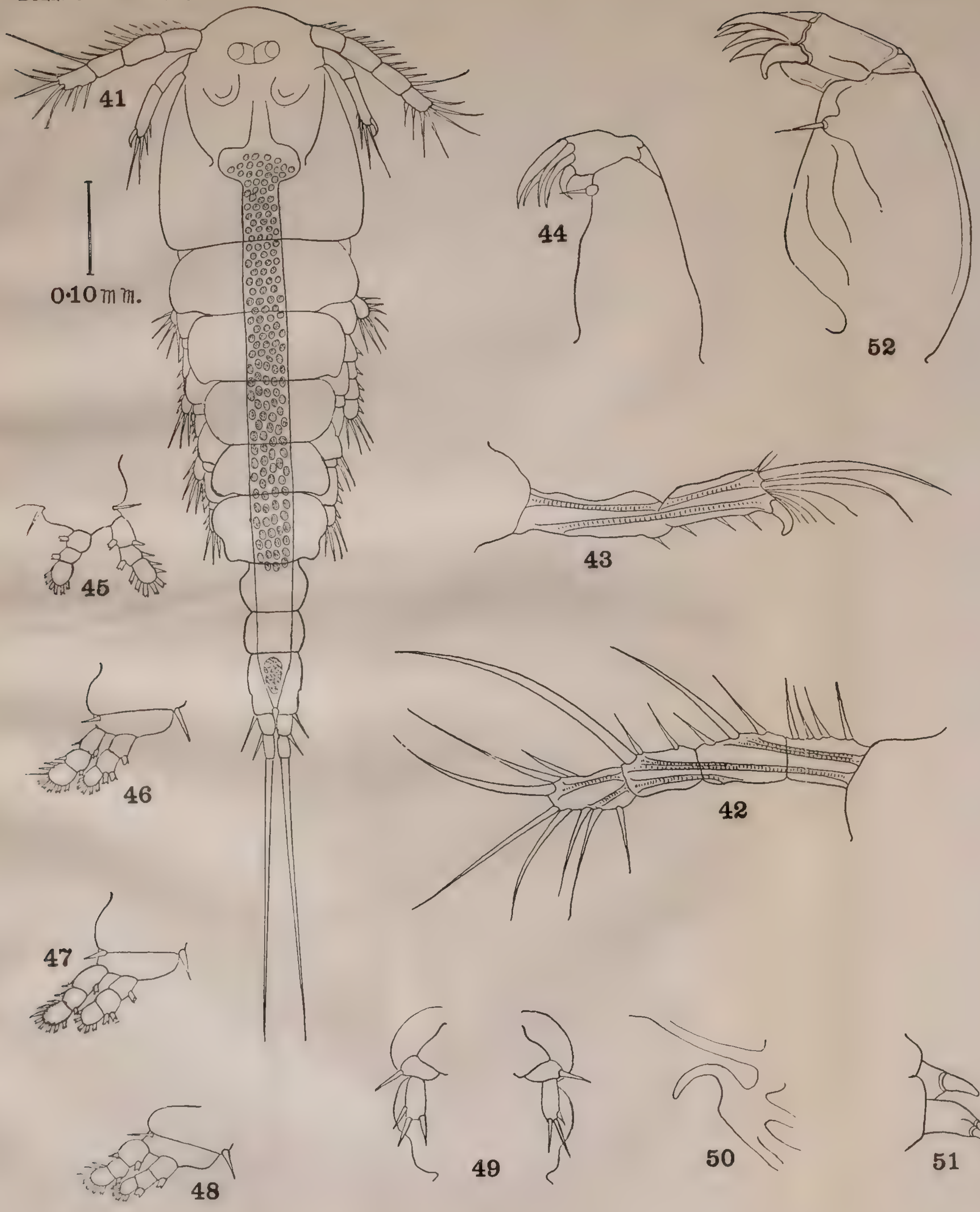
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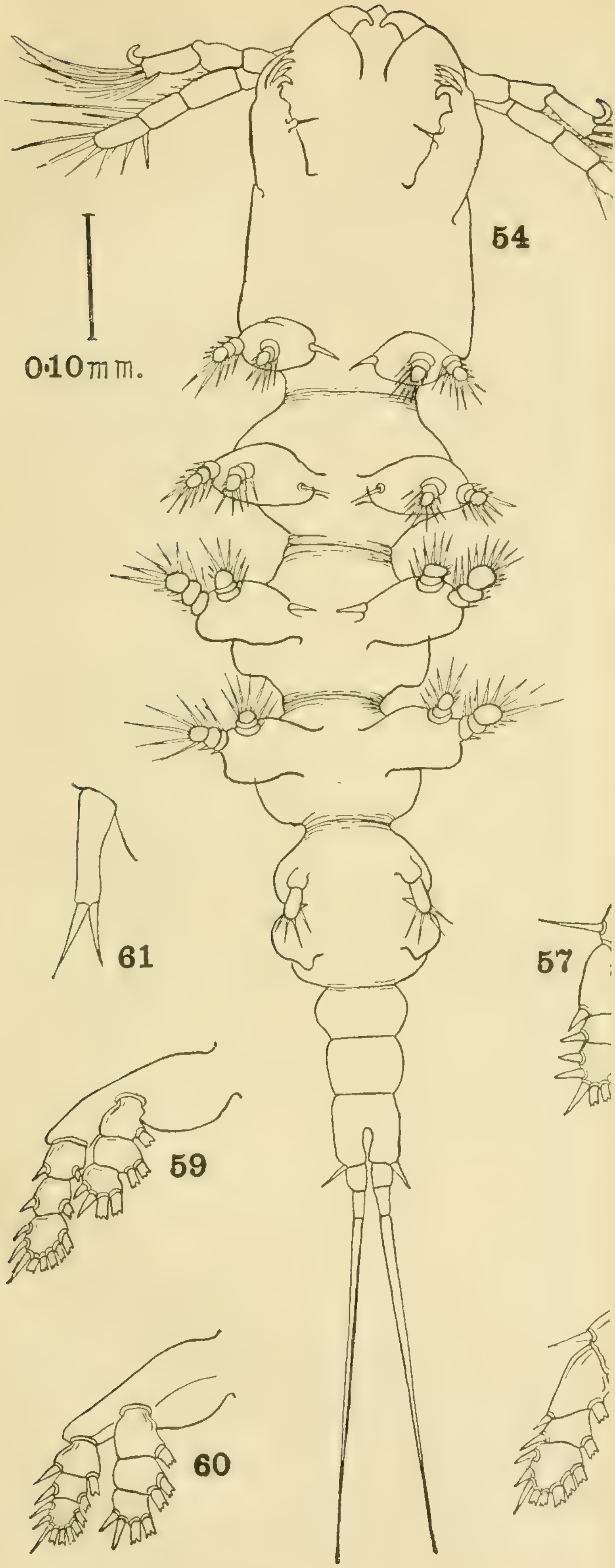
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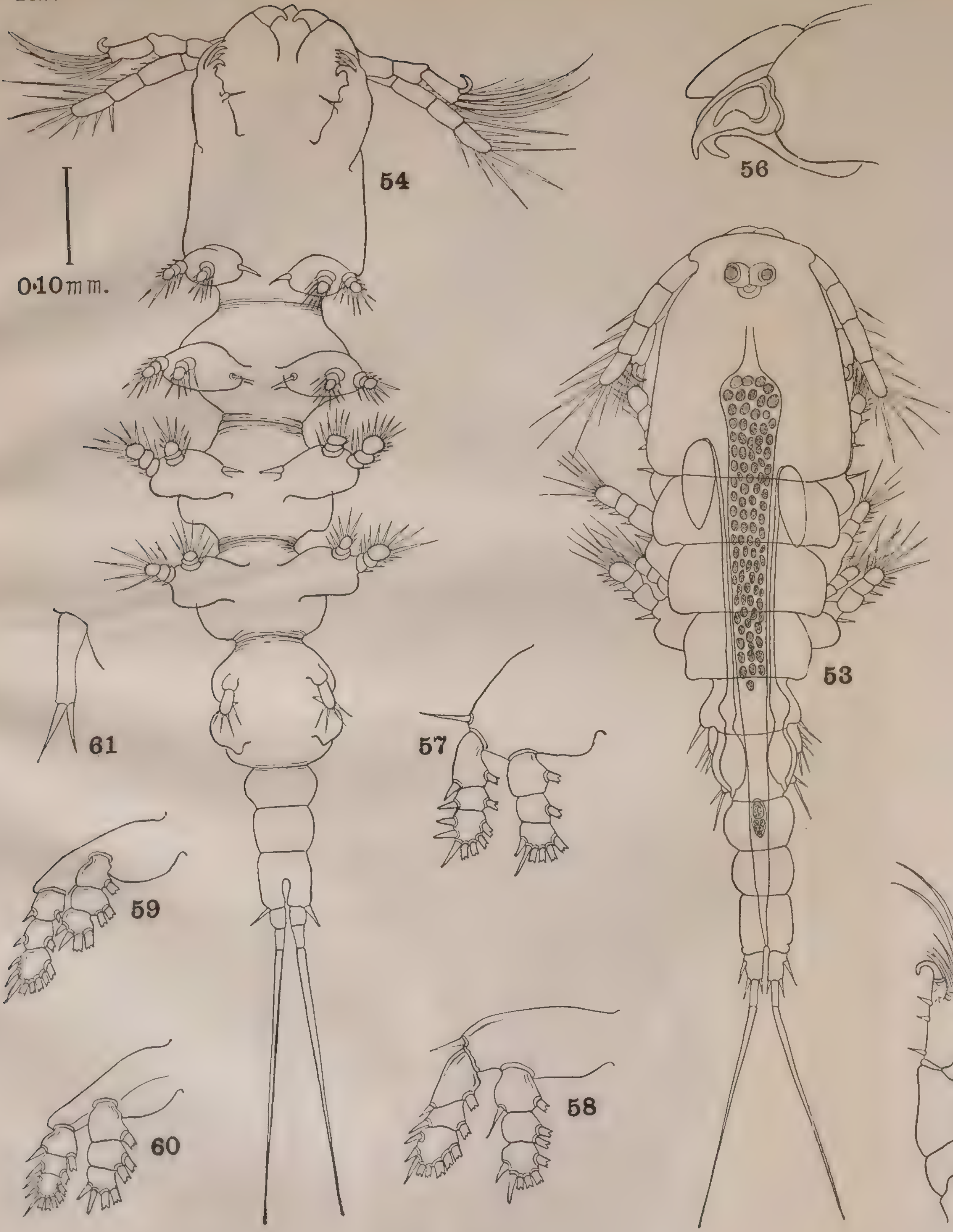
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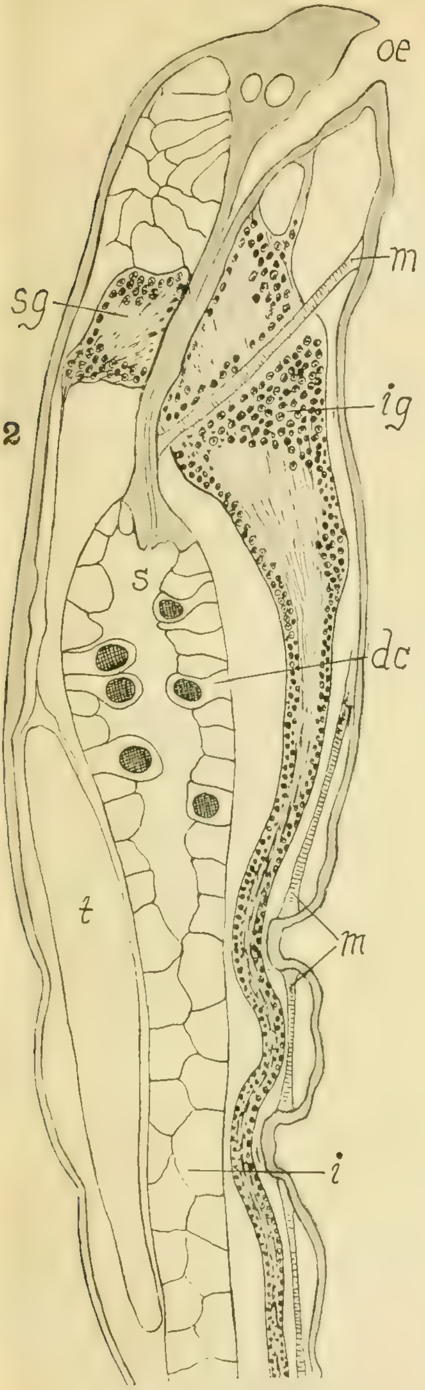
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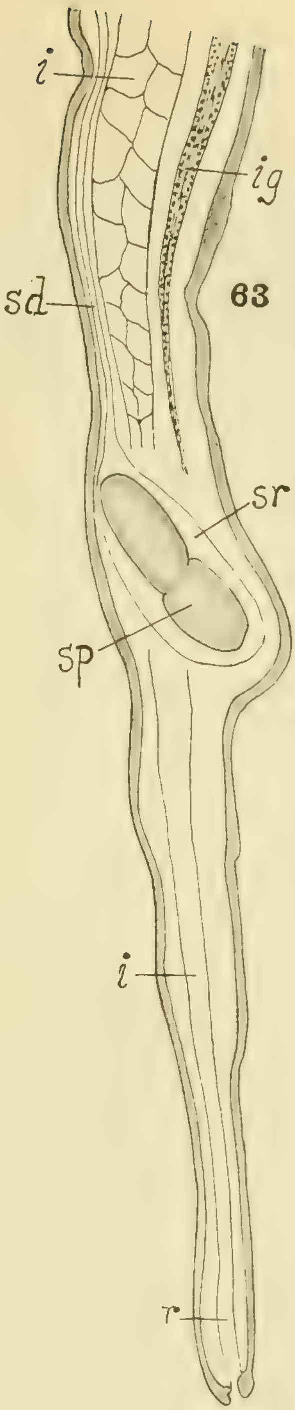
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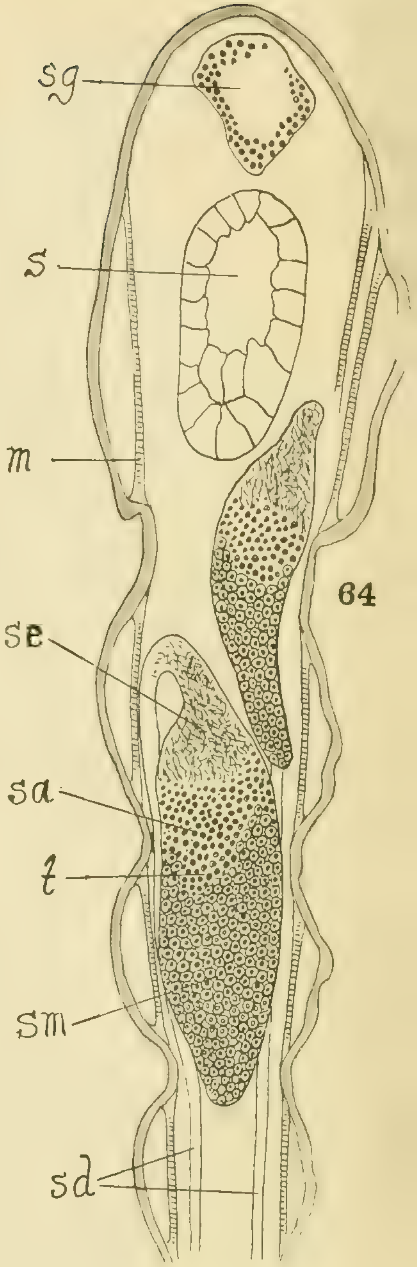
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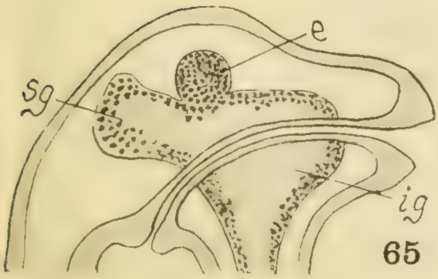
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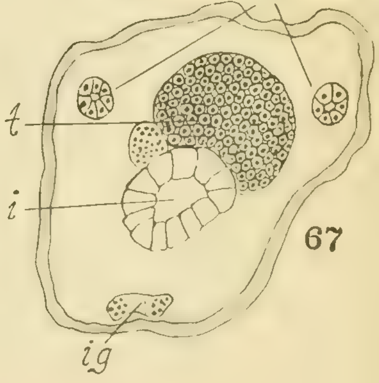
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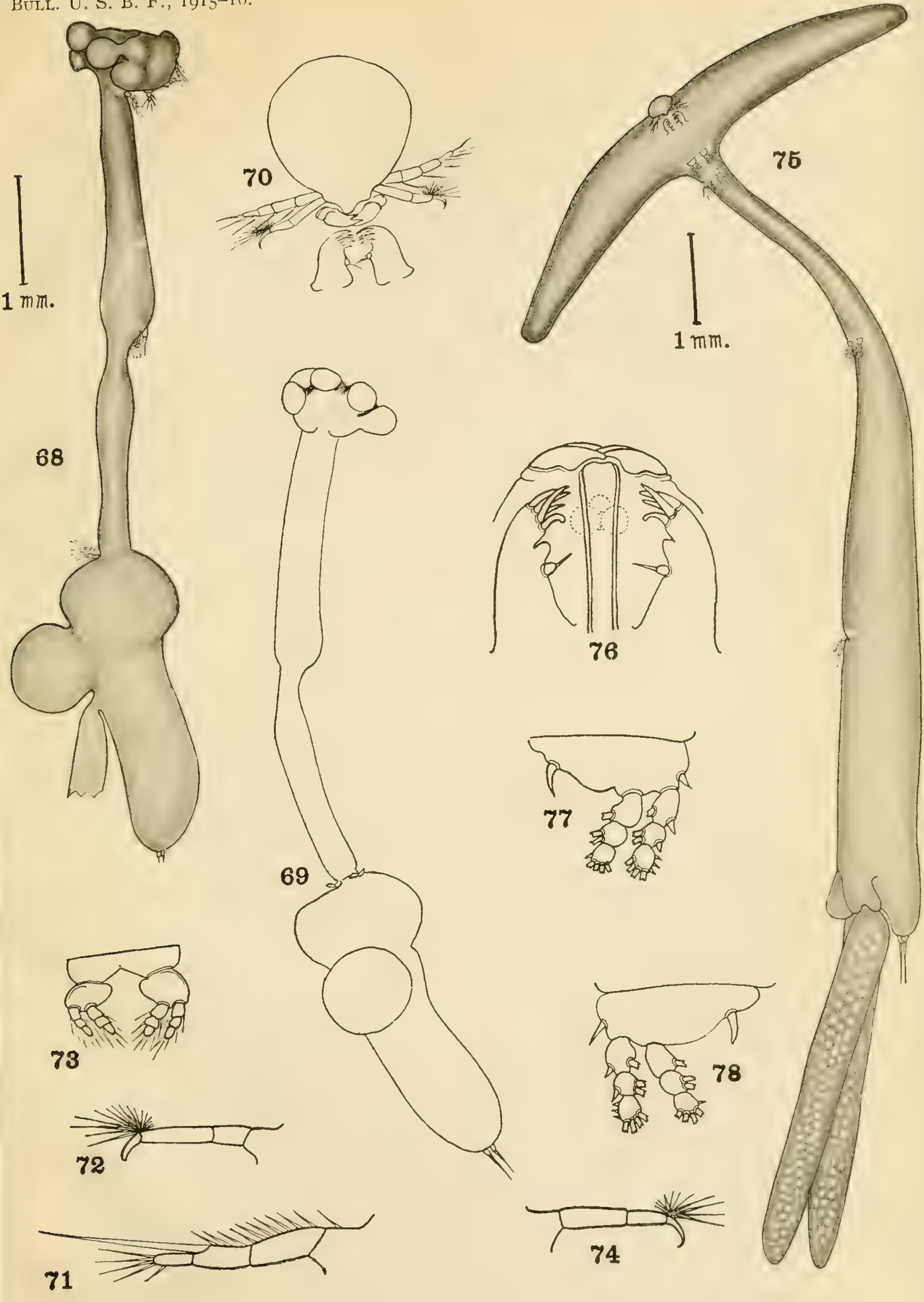
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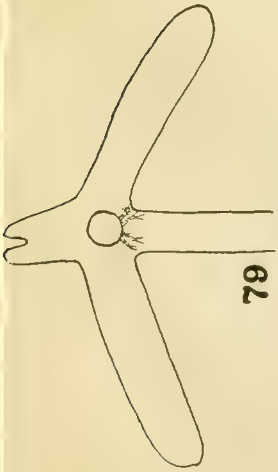
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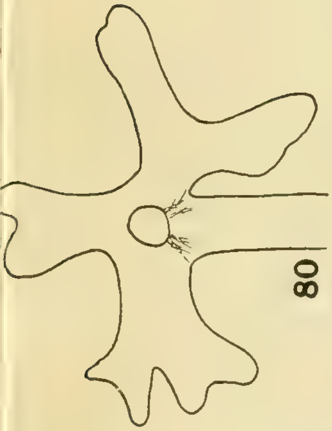
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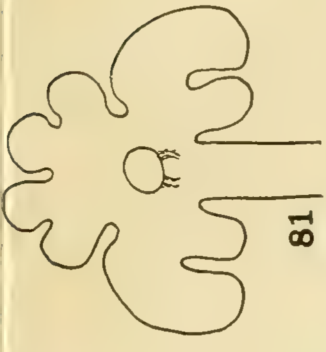
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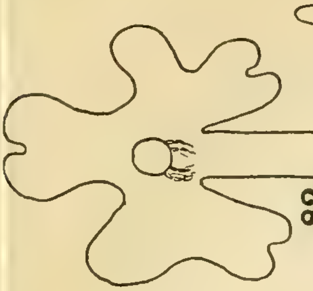
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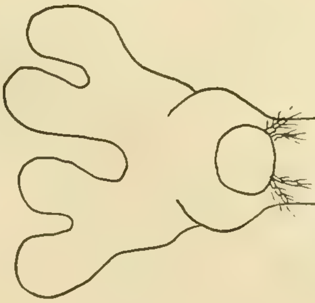
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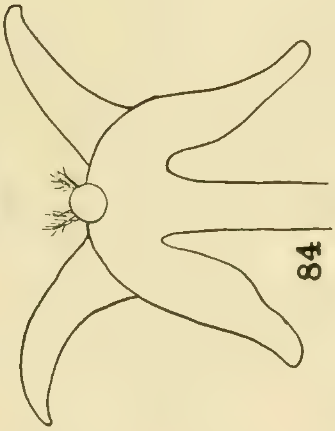
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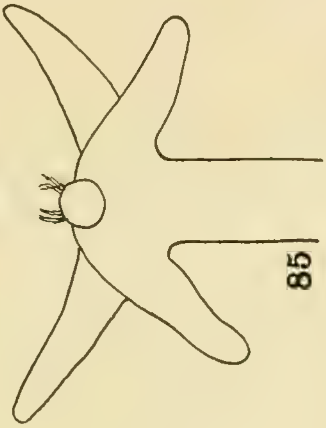
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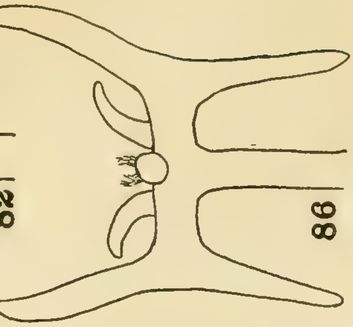
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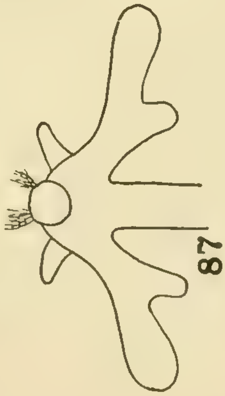
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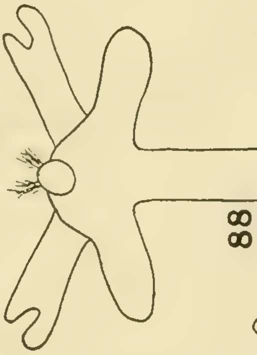
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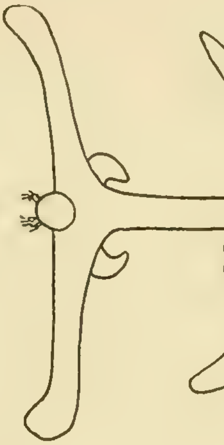
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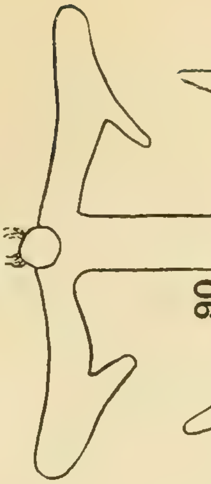
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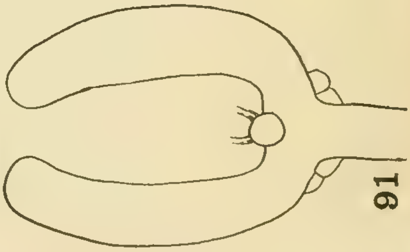
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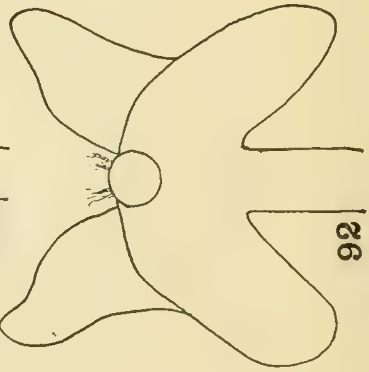
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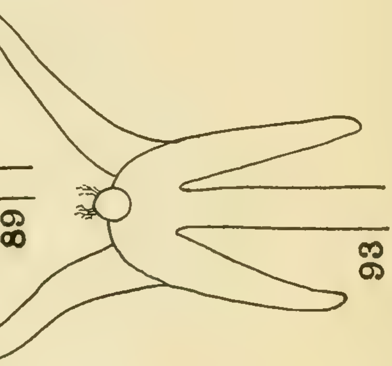
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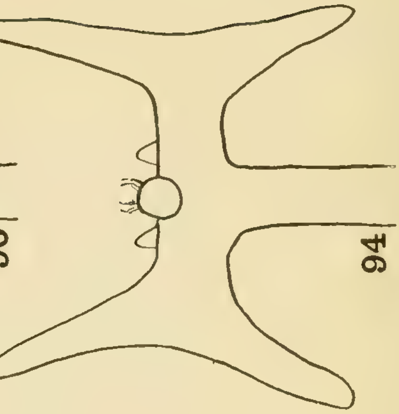
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THE MYXOSPORIDIA OF THE BEAUFORT REGION, A SYSTEMATIC AND BIOLOGIC STUDY

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Contribution from the United States Fisheries Biological Station, Beaufort, N. C.

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MYXOSPORIDIA OF THE BEAUFORT REGION, A SYSTEMATIC AND BIOLOGIC STUDY.

By H. S. DAVIS,
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Contribution from the United States Fisheries Biological Station, Beaufort, N. C.

INTRODUCTION.

For several years the writer has been engaged in a study of the Myxosporidia at the United States Fisheries Biological Station, Beaufort, N. C., and a part of the results of this work is included in the present paper.

When first undertaking the study of the Myxosporidia the author was impressed with the fact that very little work had been done on the group in this country. With the exception of Gurley's paper (Gurley, 1894), which is largely a compilation, scarcely anything has been published on the Myxosporidia by American biologists. It is therefore not surprising to find that nearly all the Myxosporidia occurring at Beaufort belong to undescribed species and in a number of cases to new genera. Some of these are of great interest, since they differ widely from previously known forms and throw a new light on many problems connected with the group.

It became evident early in the work that many American species would not conform to any accepted system of classification, and it was hoped that it would be possible to work out a more satisfactory one. As the work progressed, however, it became more and more evident that a satisfactory classification could not be developed with our present limited knowledge of the Myxosporidia, and while some important modifications of the present classification are suggested, they are to be considered merely tentative and will undoubtedly require revision as knowledge of the group increases. They are suggested primarily with the object of showing the weak points in the present classification and, it is hoped, may serve as a basis for a more satisfactory one in the future.

This paper makes no pretense of including all the Myxosporidia of the Beaufort region. Indeed, it is very certain that many species are omitted, because the author has brief and fragmentary notes on a number of species to which no reference is made in the text. It has seemed better to omit these forms entirely until more complete data have been obtained. Then, too, the investigations have been confined to the months of June, July, and August, and there is evidence that some species of Myxosporidia are more or less seasonal in their occurrence, and there may very well be species which do not occur in the adult form during these months. Furthermore, it has not been possible to examine all the species of fish commonly found in the Beaufort region. For the most part the fish examined have been those which are abundant and easily taken. While only a limited number of fish belonging to rarer species have been examined the absence of Myxosporidia in these fish can not be considered of any particular significance, since it is comparatively rare to find all the fish of any species infected with the same parasite.

For these reasons it has not been considered advisable to include in this paper a list of the fish examined, since such a list might easily lead to very erroneous conclusions.

METHODS.

The description of the trophozoites and spores have been made almost entirely from living material. They were removed to the slide from the recently killed fish and studied at once. To prevent evaporation the cover glass was ringed with paraffin of a low melting point. In the case of the trophozoites it is essential that they be studied without delay, for they almost invariably undergo degenerative changes within a few hours after the death of the host.

Some efforts have been made to grow the trophozoites on culture media, but so far without success.

While the spores are naturally much more resistant to unfavorable conditions than the trophozoites, it is nevertheless important that all descriptions be based on perfectly fresh material. There is a marked tendency in most species of Myxosporidia for sporulation to take place much more rapidly under unfavorable conditions, and spores formed under such conditions are often smaller and may show other striking variations from the typical form.

Although the descriptions in all cases have been based primarily on living specimens, fixed and stained material has been utilized in many instances. For the study of the nuclei smears made by the Giemsa method have been of great value. They were prepared as follows:

A small amount of material was spread on the cover glass to form a very thin film, which was then exposed to osmic vapor for about one-half minute. The film was then allowed to dry, fixed in absolute alcohol about one-half hour, and after drying stained by Giemsa's method for several hours. After staining they were decolorized in acetone, dried, and mounted in damar. Damar has been found to be much more satisfactory than Canada balsam for this purpose. Films mounted in damar have faded very slightly, if at all, after several years, while those mounted in neutral balsam are so badly faded after a year or two as to be of no value.

The success of this method varies greatly in different species. In some cases the nuclei are brought out with great clearness, while in others the results are very unsatisfactory.

Wet smears were also used, but in general were not as valuable as those prepared by the Giemsa method. In making these the material was spread in a thin film over the cover glass, exposed to osmic vapor for one-half minute, and then placed at once in Worcester's formol-corrosive-acetic fixing fluid for one to three hours. They were stained with Delafield's hematoxylin, iron hematoxylin, or Mayer's acid hemalum.

In the preparation of sections the best results were obtained with material fixed in Worcester's formol-corrosive-acetic fluid and stained with iron hematoxylin and congo red.

GENERAL ACCOUNT OF THE MYXOSPORIDIA.

INTRODUCTORY.

The Myxosporidia are chiefly parasites of fishes, although several have been found in Amphibia and reptiles and possibly in a few invertebrates.[a] So far as known they are all endoparasites, and no part of the fish, except possibly the digestive cavity, appears to be free from infestation. They are often described as being primarily tissue parasites, but this is a mistaken view, due to the fact that the tissue parasites often form conspicuous lesions and may be very injurious to the host. On this account they have attracted more attention, while the less injurious and less conspicuous forms occurring in various cavities in the body have largely been overlooked, although in reality much more common.

Not only are the Myxosporidia to be looked upon as occurring chiefly in various cavities of the host—at least for the greater part of their existence—but, as has been pointed out by Auerbach (1910), the "free" forms are more primitive and nearer the original ancestors of the group than the typical tissue parasites. The latter are highly specialized forms which have in all probability descended from species which lived free in cavities of the host. A number of recent writers have urged that the Sporozoa are a polyphyletic group—one division having been derived from the Mastigophora, the other from the Sarcodina. The sarcodine ancestry of the Myxosporidia is strongly indicated by the "free" forms, the trophozoites moving by means of well-developed pseudopodia and often, especially in the younger stages, appearing strikingly like Amebæ.

STRUCTURE AND ACTIVITIES OF THE TROPHOZOITES.

From what has been said it will be evident that the typical structure of the trophozoites is best shown by those forms which spend the greater part of their existence in cavities of the host. In these cases the trophozoites form plasmodia, which either float free in the fluids filling the cavities or are attached to the epithelial lining. Although the plasmodia of the same species often show considerable variations in form, it is nevertheless true that each species is characterized more or less definitely by peculiarities of form and structure, so that in many cases they can be recognized even in the absence of the spores. This is especially true when applied to the different genera, although even in this case there are numerous exceptions. For instance, in most species of *Ceratomyxa* the trophozoites are pyriform with a definite anterior end—in *Sphæromyxa* flat and leaflike, and in *Myxidium* Amebalike, with short, lobose pseudopodia. In practically all cases the trophozoites when irritated or subjected to unfavorable conditions tend to contract into a spherical mass.

Usually the trophozoites show a well-defined ectoplasm and endoplasm, but in some cases there is no distinct peripheral layer. When distinguishable, the ectoplasm may form a distinct layer all over the body or it may be recognizable only in certain regions. It is denser than the endoplasm, usually clear and homegeneous, and occasionally, as in *Myxidium lieberkühni*, *Sinuolinea dimorpha*, or *Chloromyxum leydigi*, may be covered with a layer of short hair or bristlelike processes. The more or less characteristic shape of the trophozoite is undoubtedly due to the presence of this firm outer layer, which also serves for protection and furnishes the means of locomotion, the pseudopodia being always chiefly and in many cases exclusively of ectoplasm.

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[a] The accounts of the occurrence of true Myxosporidia in the invertebrates are very few and fragmentary and badly in need of confirmation.

The endoplasm has a more fluid structure than the ectoplasm and can usually be easily distinguished by its distinctly granular appearance. It contains numerous nuclei, many of them inclosed in distinct cells, and in addition various metaplasmic products, such as fat globules, pigment granules, and crystals of various kinds. These may in some species be distributed uniformly throughout the endoplasm; in others their distribution is markedly irregular. In pyriform trophozoites they are usually much more abundant near the anterior end than elsewhere. In at least one instance (*Sinuolinea dimorpha*) the endoplasm also contains food particles in various stages of disintegration. It is often more or less distinctly vacuolated, the distinctness of the vacuoles varying greatly even in the same individual. The endoplasm, in several species of *Ceratomyxa* and *Leptotheca*, has a very remarkable structure. In addition to granules and fat globules it contains large numbers of spherules, which are often so abundant as to entirely fill the endoplasm, with the exception of a short distance at the anterior end. These spherules vary greatly in size in different species and may be homogeneous throughout or inclose crystals or pigment granules. The consistency of the spherules may vary greatly in individuals of the same species. Sometimes they are so firm and dense as to retain their shape perfectly on drying; in other individuals they are much more fluid and easily distorted and in extreme cases may apparently break down into a watery substance. It is still a question whether adult trophozoites of the same species may occur in two extreme conditions—one with well-defined, dense spherules, the other with no trace whatever of spherules—and in all intermediate conditions. This is doubtless true in the case of very small trophozoites, the spherules only appearing as they grow larger, but there is also evidence that full-grown trophozoites may sometimes fail to develop spherules. In a few cases, notably in *Ceratomyxa attenuata*, rod-shaped bodies strikingly like bacteria were present in the endoplasm.

The sole method of locomotion is by means of pseudopodia, which vary greatly in shape and structure in different species. Sometimes they are long and filiform, in other cases short and conical, in still others branched or even arborescent, or, finally, they may be broad and coarsely lobate. In pyriform trophozoites, in addition to the numerous filiform pseudopodia, there is usually a rapid wavelike movement of the ectoplasm at the anterior end, very characteristic and very difficult to describe.

There is still considerable uncertainty in regard to the actual mode of progression among the Myxosporidia. In the case of those having lobose pseudopodia the problem is the same as in Ameba, and it is unnecessary to consider it further here. But in most species of *Ceratomyxa* and *Leptotheca* the trophozoites are pyriform and capable of comparatively rapid progressive movements in one direction only. Consequently a large, rounded, anterior end can be distinguished, while the posterior end usually terminates in a long, slender, tapering process, termed, by Doflein (1898) the "Stemmpseudopodien." At the anterior end are formed numerous, long, filiform pseudopodia. According to Doflein, locomotion in such cases is chiefly due to the "Stemmpseudopodien," which by elongation pushes the body forward. However, after a careful study of the movements of such trophozoites, the writer is convinced that locomotion is due entirely to the pseudopodia at the anterior end. Many times trophozoites have been seen moving rapidly forward when the posterior process extended out freely behind and was attached to neither the slide nor cover glass. This was conclusively shown when the trophozoite turned quickly to one side; the posterior process swept around and continued to extend straight out behind, which could not have been the case if it was attached. In a few cases in turning the process hit an object and was then bent to one side. In one instance a sporulating trophozoite of *Leptotheca scissura*, which was entangled on the slide in a bit of débris was observed. In its efforts to escape the body became greatly elongated by the pulling of the pseudopodia at the anterior end until it finally became small enough to be pulled free. It is true that the posterior process can sometimes be seen to elongate as the trophozoite moves forward, but that only occurs when it adheres to some foreign object and is consequently pulled out into a long, slender process by the pseudopodia at the anterior end.

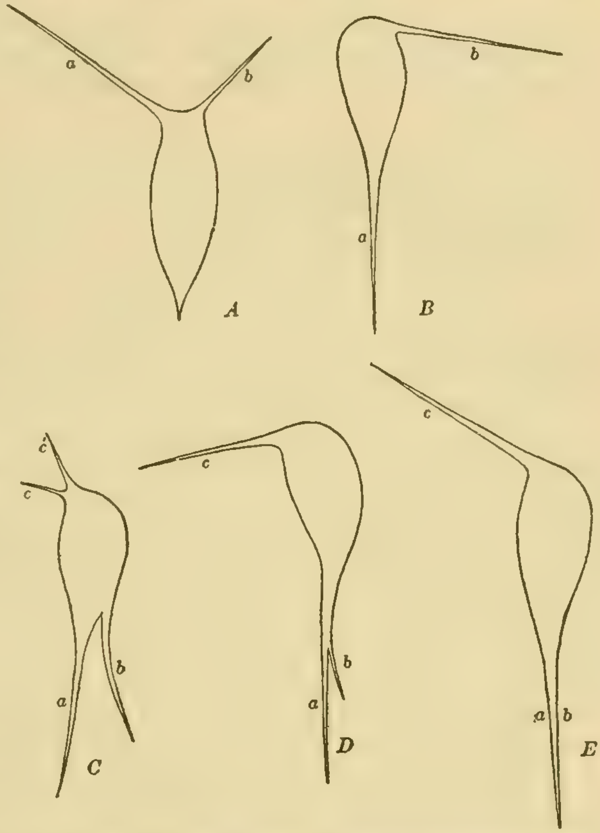

FIG. 1.—Movements of pseudopodia in a vegetative trophozoite of either *Leptotheca* or *Ceratomyxa* sp. from the gall bladder of *Cestracion tiburo*. *A*, trophozoite with two long pseudopodia, *a* and *b*, at anterior end. *B*, 10 minutes later, *a* has moved to posterior end of body, *b* has elongated and is also moving toward posterior end. *C*, 1 minute later, *b* has nearly reached posterior end and 2 new pseudopodia, *c* and *c*, have appeared at anterior end. *D*, 3 minutes later, *c* and *c* have fused, *a* and *b* have nearly fused. *E*, 10 minutes later, *a* and *b* are completely fused and *c* has increased in length. × 1000.

Under dark-ground illumination the long, filiform pseudopodia can be seen to be thrust forward and then sweep posteriorly toward the sides of the body, as in figures 3–7, plate XVI, and figure 43, plate XIX. Movements of these pseudopodia in all directions can be plainly seen; in fact, they move about much like flagella. It is also certain that the filiform pseudopodia can be rapidly absorbed and reformed. Text figure 1 shows clearly the formation of these pseudopodia in a trophozoite which had been on the slide for some time, and consequently the movements were so slow that they could be easily followed.

In most cases, possibly in all, in addition to the filiform pseudopodia, short, conical, and branched pseudopodia are formed at the anterior end. These are difficult to see, as they are very transparent and continuously changing. They are simply an exaggerated form of the wavelike movements of the ectoplasm noted above, which are so characteristic of pyriform trophozoites. In the intense light of the dark-ground illuminator the filiform pseudopodia are often retracted after a short time, locomotion then being accomplished entirely by these short, conical, or branched pseudopodia. The same is usually true of trophozoites which have been on the slide for some time, locomotion in such cases becoming slower and the filiform pseudopodia entirely disappearing.

REPRODUCTION AND INFECTION OF NEW HOSTS.

In the case of parasitic protozoa Doflein (1898) has distinguished between multiplicative and propagative reproduction. The former results in the increase of the parasite within the host; the latter provides a means by which the parasite may gain entrance to a new host.

There is still a great deal of uncertainty regarding the methods of multiplicative reproduction in the Myxosporidia, and more knowledge on the subject is badly needed. It is, however, a problem which is peculiarly difficult of solution, especially in the "free" forms. According to Doflein, multiplicative reproduction in these forms is entirely by plasmotomy. In most cases the plasmodium separates into two equal or nearly equal parts. However, in *Myxidium lieberkühni*, according to Cohn (1896), multiplicative reproduction is accomplished by a method of exogenous budding. In a former paper (Davis 1916) reasons have been given for believing that the process observed by Cohn is abnormal and has nothing to do with reproduction. In *Sinuolinea dimorpha* (Davis 1916), a method of multiplicative reproduction by endogenous budding has been demonstrated. This method consists simply in the formation of gemmules from the generative cells within the mother trophozoite. These later emerge and give rise to new individuals. There is evidence that a similar process occurs in several species of *Ceratomyxa* and *Sinuolinea*, and the writer has no doubt that this is a common method of multiplication among the "free" forms. Possibly this method may be considered a form of plasmotomy, but if so it is certainly quite different from the process described by Doflein.

In the tissue parasites multiplicative reproduction by a process of multiple division or schizogony has been described by Doflein, Keysselitz (1908), Nemeczak (1911), and Hahn (1915).

Propagative reproduction, so far as known, is always by means of spores, which enables the organism to resist the unfavorable conditions which it may encounter in gaining entrance to a new host. The process of sporulation is a very complicated one and can not be gone into here. (See Auerbach (1910), Minchin (1912), and Davis (1916).) The spores are usually formed in pairs, each spore being composed of six cells (eight in *Chloromyxum*). Two of these cells form the outer protective covering, the sporocyst; two form the capsules; while the remaining two cells form the binucleate sporoplasm. The number of spores formed by a single trophozoite varies from one to a large number, and we often find considerable variations in this respect within the same species, for example, *Ceratomyxa multispora* and *Sinuolinea dimorpha*. In the case of the monosporous and disporous trophozoites the spores are set free by the death and disintegration of the mother trophozoites. In the polysporous trophozoites the spores may all be formed at the same time, as in the disporous forms, and liberated in the same way. More commonly, however, the formation of spores continues for some time, the mature spores being successively set free as new ones develop.

In the case of species inhabiting the gall or urinary bladders it is, of course, a simple matter for the spores to reach the exterior. I have many times observed the spores of gall parasites in the intestine and rectum, whence they doubtless pass out with the feces. That the spores formed in the gall and urinary bladders pass out quickly after being set free is indicated by the fact that free spores are always comparatively rare in such cases, although there may be an abundance of sporulating trophozoites present.

It is interesting to note in this connection that, in many species at least, adverse conditions tend to hasten the process of sporulation. It has often been observed that after the death of the host or after being removed to the slide those trophozoites in which sporulation is well advanced mature their spores in a very short time. Such spores are often smaller than those formed under normal conditions.

It is obvious that in the tissue parasites the spores in many cases will not be able to reach the exterior until after the death and disintegration of the host. In other cases, however, the cysts may break open either on the outer surface or into some cavity of the body, whence they may easily make their escape. In a number of instances spores of *Myxobolus* in the gall bladder and intestine have been noted.

After reaching the exterior the spores are apparently dependent on chance in entering a new host. There is no evidence of secondary or intermediate hosts, although such a possibility is by no means excluded. On the theory of purely accidental infection it is somewhat difficult to account for the high percentage of infection met with in many instances. For example, although a large number of individuals of the squeteague, *Cynoscion regalis*, were examined, not one was found infected with *Sinuolinea dimorpha*. The gall bladder of the pipefish, *Siphostoma floridæ*, is always infected with *Sphæromyxa balbianii*, although in this case an infection of 100 per cent is not so difficult to explain on account of the feeding habits of the host. Similarly, the gall bladders of sharks and rays are, except in the case of very young individuals, practically always infested with one or more species of Myxosporidia. It has been suggested that the processes of various kinds with which so many of the spores are provided enable them to float for a much longer time and thus increase the chances of their being taken into the proper host.

So far as known the spores do not germinate until after reaching the stomach or intestine of the host. This would seem to decrease the chances of infection to a considerable extent, since most of the spores carried into the mouth in breathing would in all probability be swept out again through the gill openings. It would be interesting to follow the fate of the spores in case the host is devoured by another fish.

On reaching the intestine the valves of the spore separate under the influence of the digestive fluids, allowing the sporoplasm to creep out as a minute amœbula, which by actively crawling along the ducts or by entering the blood vessels finally gains access to the organ in which it is destined to undergo further development. The action of the digestive fluids has been shown by Auerbach, Thelohan, and others to cause the extrusion of the filaments from the capsules. It has been supposed that the function of these organs is to attach the spore to the wall of the gut, but it would seem much more probable that the filaments would simply become entangled in the partly digested food and swept along toward the rectum. Since in the few cases in which the germination of the spore has been investigated the sporoplasm emerged in a very short time after the spore was brought in contact with the intestinal fluids, it is not obvious just what purpose would be served by the attachment of the spore to the intestinal wall. In short, it is believed that the function of the capsules which form such a conspicuous part of the spore has not been demonstrated.

According to Auerbach (1910) and Erdmann (1911) there is, even in the "free" forms, a short stage of intracellular existence, the newly emerged sporozoite entering an epithelial cell and multiplying by binary fission. In these species, however, the period of cell parasitism is comparatively brief, and the greater part of their existence is spent in the cavity of the infected organ, either attached to the epithelium or floating freely in the bile or urine. According to Auerbach, the intracellular phase is followed by the fusion of two planonts, the nuclei remaining separate, thus forming a binucleate trophozoite, which he believes develops into the spore-forming plasmodium. The sexual phenomena are, however, so complicated and the accounts of different writers so fundamentally diverse that it is not thought best to go into the subject at this time.

THE SPORE.

Since the spore is practically the only organ in the Myxosporidia having a well-defined structure the details of which are nearly constant for each species, it has always been the principal character used in distinguishing the different species. For this reason it is of the greatest importance to have a clear understanding of the fundamental structure of the spore. Unfortunately most writers have based their conception of the myxosporidian spore primarily on that of *Myxobolus*. It has already been pointed out that there are good reasons for believing that the Myxobolidæ represent the most highly specialized group of the Myxosporidia, and this specialization is as evident in the spore as in the plasmodium. A truer conception of the myxosporidian spore can be obtained from the study of those of less specialized genera, such as *Leptotheca* or *Ceratomyxa*. Text figure 2 shows diagrammatically the structure of the spore based primarily on *Leptotheca*. Surrounding the spore is a thin, tough, transparent membrane, the sporocyst (*sp'c.*), which is probably of a chitenoid nature. The sporocyst is composed of two valves, each valve being developed from a single parietal cell. The more or less degenerate nucleus of the parietal cell (*par. n.*) can often be distinguished in the mature spore. The valves of the sporocyst are united along the sutural line (*s. l.*), which usually forms a more or less distinct ridge around the spore. Within the sporocyst are the capsules and the sporoplasm or sporozoite.

The capsules [a] (*cap.*) are typically two in number, but in some cases there may be only one, as in a few species of *Myxobolus*, or four in *Chloromyxum*. Each capsule is formed within a capsulogenous cell (*cap. c.*), which can usually be more or less clearly distinguished even in the ripe spore. The capsules are usually pyriform, sometimes approximately spherical in shape, and drawn out at one side into a short, narrow duct opening to the exterior through a minute pore which is always situated along the sutural line. Surrounding the capsule is a tough, refractive envelope, probably chitenous. Coiled up within the capsule is a delicate filament (*fil.*), usually of comparatively great length, which is probably of the same material as the capsule, with which it is continuous at the end of the duct. In spores containing two capsules the filaments in each are always coiled in opposite directions—i. e., one is the mirror image of the other. Under suitable stimulation the filaments are everted through the pores in the sporocyst in much the same way as in the case of the coelenterate nematocyst. The sporoplasm (*sp'p.*) is a finely granular, translucent mass of protoplasm, which commonly fills most of the space within the sporocyst not occupied by the capsulogenous cells. In the fully matured spore, expecially after it has left the body of the host, the sporoplasm may become rounded. It is usually situated in the middle of the spore, extending equally into both valves, but in some cases (many *Ceratomyxa*) may be unsymmetrically located, sometimes being confined entirely to one valve. Within the sporoplasm are two nuclei (*sp. n.*), which usually lie close together, often in contact. In addition to the nuclei there are often several small, fat globules present and in the Myxobolidæ the characteristic "iodinophilous vacuole," which is probably composed of glycogen. The liquid-filled space (pericystic space) within the spore not occupied by either the capsulogenous cells or sporoplasm often contains numerous granules and small fat globules.

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[a] The capsules have been termed "polar capsules" by most writers, but I agree with Gurley (1894) that it is better to refer to them simply as capsules, since they are often not in the position indicated by the term polar capsule.

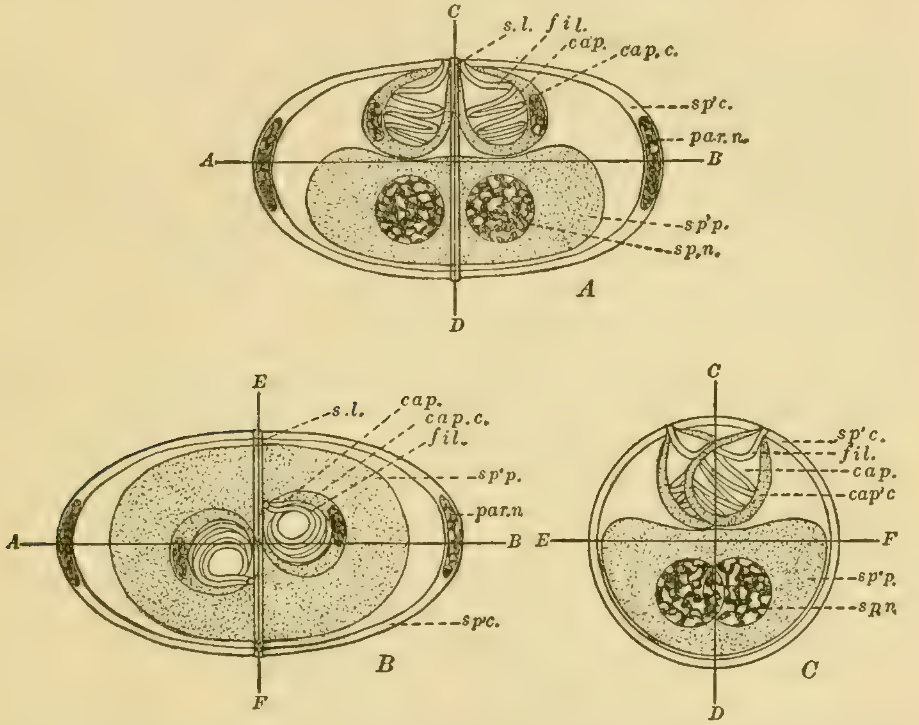

FIG. 2.—Structure of myxosporidian spore based primarily on *Leptotheca*. *A*, viewed from above; *B*, viewed from the capsular side; *C*, viewed from one end; *A–B*, longitudinal axis; *C–D*, transverse axis; *E–F*, vertical axis; *cap.*, capsule; *cap. c.*, capsulogenous cell; *fil.*, filament; *par. n.*, nucleus of parietal cell; *s. l.*, sutural line; *sp'c.*, sporocyst; *sp'p.*, sporoplasm; *sp. n.*, nuclei of sporoplasm.

The spore is usually bilaterally symmetrical, the sutural plane forming a plane of symmetry, but to this rule there are numerous exceptions, and in a few cases the shape of each valve of the sporocyst is quite different.

For descriptive purposes it is necessary to recognize certain topographic features in the spore. Unfortunately, somewhat ambiguous terms have been used by various writers which are likely to lead to confusion. The most objectionable are the terms "anterior" and "posterior" ends, first used in this connection by Thelohan. While the terms may not be open to serious objection in the case of *Myxobolus*, they are very inappropriate, to say the least, when applied to the spores of certain other genera. On this account it has seemed best to propose a slightly different terminology than that used by previous writers.

The position of the capsules in such genera as *Ceratomyxa*, *Leptotheca*, or *Myxobolus* indicate the capsular side or end (anterior end of Thelohan). The opposite side surrounding the sporoplasm is designated the postcapsular side. The plane extending between the capsules from the capsular to the postcapsular sides and dividing the spore into two symmetrical halves is the transverse plane (vertical plane of Gurley). The transverse plane is the plane of symmetry and may or may not coincide with the sutural plane. The longitudinal plane is the plane passing through the capsules and sporoplasm at right angles to the transverse plane and divides each valve into a superior and inferior half which are symmetrical with each other. The vertical plane (transverse plane of Gurley) is the plane passing approximately between the capsules and the sporoplasm at right angles to both the transverse and longitudinal planes, dividing the spore into unsymmetrical capsular and postcapsular regions.

The longitudinal axis (fig. 2, *A–B*) is the line formed by the intersection of the vertical and longitudinal planes. The transverse axis (fig. 2, *C–D*) is the line formed by the intersection of the transverse and longitudinal planes. The vertical axis (fig. 2, *E–F*) is the line formed by the intersection of the vertical and transverse planes.

The length of the spore is the distance along the longitudinal axis, and in case the valves are curved the axis is supposed to have a corresponding curvature. The width is the distance between the capsular and postcapsular sides along the transverse axis, while the thickness is the length of the vertical axis. In the case of the capsules when only one dimension is given it is always the longest diameter.

Although always constructed on the same fundamental plan, the modifications of form and structure which the spores may exhibit in different species are almost endless. However, even a cursory study shows that some modifications are much more fundamental than others. The former are of great value in differentiating between the different families and genera, while the latter are our main reliance in distinguishing the different species. Among the more important and deep-seated modifications may be mentioned the general form of the spore and the position and number of the capsules (cf. fig. 3–4). The principal specific differences consist of minor modifications of form, appendages of various kinds, markings on the exterior of the sporocyst, position of the capsular pores, and size, including in the latter term not only the size of the spore as a whole but the relative sizes of the different parts.

Of course, as in all systematic work, there is the possibility of variations in these characters within the limits of the species. This is a problem regarding which there are very little data at present. There seems to be a general consensus of opinion among writers on the Myxosporidia that the spores show comparatively little variation, but so far as known there have been no special investigations in regard to this point. With this belief in the constancy of the spores the writer is in general agreement. The greatest intraspecific variation seems to be in size, and many writers have overestimated the importance of this as a specific character. As previously pointed out, there is a marked tendency in many species to form spores rapidly when subjected to unfavorable conditions, and such spores are very often undersized and also sometimes show considerable modifications in form. There is evidence that spores from different hosts may show greater differences than those from the same host, but special attention has not been given to this point, which is well worth extended investigation. There is, of course, a possibility that some of the forms described as distinct are simply different strains of the same species developed in different host species.

OCCURRENCE OF THE MYXOSPORIDIA.

The more the writer has studied the Myxosporidia the more confident he has become that no group of fishes are free from these parasites. It was only a few years ago that the Pleuronectidæ was pointed out as an example of a family which was immune to the attacks of Myxosporidia, but now a number of species are known from fishes of this family. The author has found several species of Myxosporidia in one species of flounder, *Paralichthys albiguttus*, and it is rare indeed to find a fish that is not infected by one or more of these parasites. The ganoids have also been believed to be free from Myxosporidia, but there has been found a species of *Sphærospora* abundant in the urinary bladder of the gar pike, *Lepisosteus platystomus*, at Gainesville, Fla.

Although numbers of species of fishes were examined without finding any evidence of Myxosporidia, it is doubtful if there are many fishes which are absolutely free from these parasites at all times. In most cases the species in which Myxosporidia were not found are those in which only a few fish or only young individuals have been available for examination. Probably the most striking exception is the menhaden, *Brevoortia tyrranus*, of which large numbers of adults were examined with uniformly negative results. But negative results in such cases are far from conclusive when it is considered that some species of Myxosporidia occur only at certain seasons and at other times no trace of them is to be found. A striking example of this is *Ceratomyxa streptospora*, new species, which is found in the gall bladder of *Chætodipterus faber*. This species was abundant in nearly every fish examined during the early part of June, but no trace of it was found in fish examined during July.

The occurrence of some species only at certain seasons is probably not a rare phenomenon, but to what extent this occurs can only be determined by investigations carried on throughout the year. In this connection it is interesting to find that in a number of species only the vegetative forms occur at certain seasons. The best-known example of this is *Myxidium lieberkühni*, a parasite in the urinary bladder of the European pike, *Esox lucius*. Although this species is very abundant, the spores are to be found only in summer, while during the winter the epithelium of the bladder is fairly covered with immense numbers of vegetative trophozoites. The writer has found a number of forms which are not included in this paper, since none but the vegetative trophozoites were discovered, and without the spores it was impossible to determine with certainty the genera to which they belong. In a number of other instances the vegetative trophozoites were very abundant, occurring in a large proportion of the fish examined, and yet the spores were so rare that they were found only after a long and arduous search. In the case of some species practically all stages in the development of the trophozoites can be found in a single host; in others, all the trophozoites in the same fish are at about the same stage of development.

As has been previously noted by Auerbach (1910) and others, the susceptibility of fish to infection by Myxosporidia varies markedly with age. Auerbach found that in *Gadus virens*, which is parasitized by *Myxidium bergense*, the very young fish were practically free from parasites, while the half-grown fish were much more commonly infected than the adults. The author's experience has been that in general young fishes are rarely infected, while the maximum infection is to be found in nearly grown or adult fishes. This is strikingly shown in the sharks, the gall bladders of which are always infected with one or more species of Myxosporidia, except in the case of very young individuals. In young sharks less than 15 inches in length the author has very rarely found any trace of these parasites. It is also noteworthy that the young fish of any species when infected usually contain only a comparatively few trophozoites, which for the most part show no traces of spores.

Taking all the above facts into consideration, it is remarkable that such a large proportion of the fish examined should have been found to be infected.

As regards the site of the parasites within the host, the "free" forms appear to be confined for the most part to the gall and urinary bladders. A few species are found in the urinary tubules and ducts, but so far as known they are never found in the lumen of the digestive tract.

The tissue parasites are found chiefly in the connective and muscular tissues, although other classes of tissues are by no means immune, and a few species are known to attack the nervous system. The parasite may be concentrated at one spot in the tissues to form a distinct cyst, which is usually visible to the naked eye, or may spread in an irregular manner through the tissue, producing a condition known as "diffuse infiltration." The tissue parasites, although abundant in fresh-water fishes, are rare in marine fishes. They were only met with in a few species, and in every case these were fishes which also occur in brackish or fresh water.

It is often stated that parasites of the kidneys and urinary bladder are also confined chiefly to the fresh-water fishes, while parasites of the gall bladder are just as characteristic of marine species. With this the author is unable to agree. In marine fishes Myxosporidia were found to be fully as abundant in the urinary as in the gall bladder. On the other hand, such limited observations as were made on fresh-water fishes indicate that they are by no means rare in the gall bladders of these fishes.

As a general rule, each species of Myxosporidia is confined to one, or at most a few, closely related species of fishes, but to this rule there are numerous exceptions, and in some cases the parasites may occur in very different hosts, as, for example, *Sphæromyxa balbianii*, which occurs in the gall bladder of *Motella maculata* and *Siphostoma floridæ*.

Some genera appear to show a preference for certain organs of the host. The Ceratomyxa are chiefly parasites of the gall bladder, although a few species are known from the urinary bladder. In the case of *Sphæromyxa* all the known species are from the gall bladder. On the other hand, the species of *Sphærospora* are, with one exception, all found in the urinary bladder. There is no known instance of the same species inhabiting both the gall and urinary bladders, but the tissue parasites do not seem to be so particular, many species being able to develop in quite different tissues.

It is very common to find two or more species of Myxosporidia living in the gall or urinary bladders at the same time. This is especially true of the sharks, where it is rare to find an adult whose gall bladder does not contain at least two species. For instance, the gall bladder of a sharp-nosed shark, *Scoliodon terræ-novæ*, 102 cm. long, taken on August 9, 1912, contained large numbers of trophozoites and spores of at least four species—*Chloromyxum leydigi*, *Ceratomyxa abbreviata*, *C. tænia*, and *C. sphairophora.*

PATHOGENESIS.

As a group the Myxosporidia are not particularly injurious. Considering their abundance this is indeed fortunate. Undoubtedly the same factors have been at work here as elsewhere to produce this result. As has often been pointed out, it is to the advantage of the parasite as well as the host to injure the latter as little as possible. Probably the majority of the most injurious species which have arisen have accomplished their own downfall along with that of the host.

As we would naturally expect, the tissue parasites are much more injurious than the "free" forms. Several of the former are known to be the cause of some of the most destructive diseases of European fresh-water fishes.

Apparently the "free" parasites for the most part cause but little injury to the host. Like so many other protozoan parasites which are common in the cavities of both vertebrates and invertebrates, they seem to have been able to establish relations with the host which admit of the minimum amount of injury. Still, it can hardly be claimed that they are perfectly harmless. Their brief period of intracellular existence must result in the destruction of the epithelial cells in which they develop. In many cases, when specially abundant, they cause the atrophy or hypertrophy of the epithelium lining the cavities in which they develop. Whether they may produce toxic products of any kind which when absorbed by the host may have far-reaching effects we have no certain knowledge. It has been noticed that the bile in gall bladders containing large numbers of parasites is often more watery and has a lighter color than normal, but whether this is of any significance the author is unable to say. Of course, any weakening effects of the parasites on marine fishes would in most cases be difficult to detect. It would, in all probability, simply result in their being quickly captured by some one of their numerous enemies, and the chance of finding fishes which were appreciably weakened would be slight indeed.

CLASSIFICATION.

The classification of the Myxosporidia is at present in a very unsatisfactory state. The most common classification is that of Doflein (1899 and 1901). This classification, slightly modified by Auerbach (1910), is as follows:

Suborder MYXOSPORIDIA Butschli.

Legion I. DISPOREA, Doflein.

Only one pansporoblast, forming two spores, developed in each trophozoite. Trophozoites disintegrate after the spores mature.

Family 1. CERATOMYXIDÆ Doflein.

Trophozoites floating freely in various cavities of the host; progressing by amœboid movements. Long diameter of spore at right angles to sutural plane.

Genus 1. **Leptotheca** Thelohan.

Valves of the spore short and rounded.

Genus 2. **Ceratomyxa** Thelohan.

Valves of the spore produced into long, conical processes.

Legion II. POLYSPOREA Doflein.

Each trophozoite produces more than one, usually a number, of pansporoblasts.

Family 1. MYXIDIIDÆ Thelohan.

Spores with two capsules.

Genus 1. **Sphærospora** Thelohan.

Spores spherical.

Genus 2. **Myxidium** Butschli.

Spores more or less fusiform with capsules at each end. Longest diameter along the sutural plane.

Genus 3. **Sphæromyxa** Thelohan.

Spores fusiform with truncated ends. Capsules opening at the ends. Filaments short and thick; coiled parallel to the longitudinal axis. Trophozoites forming a flattened disk.

Genus 4. **Zschokkella** Auerbach.

Spores when viewed from above semicircular; pointed at the ends. Capsules spherical; situated at ends of spore but opening on the flattened surface. Sutural line curved.

Genus 5. **Myxosoma** Thelohan.

Spores ovoid, flattened, elongated, and pointed at the capsular end.

Genus 6. **Myxoproteus** Doflein.

Spores somewhat pyramidal, with spinous processes from the base of the pyramid.

Genus 7. **Lentospora** Plehn.

Spore lenticular; resembling *Myxobolus* but without iodinophilous vacuole in the sporoplasm.

Family 2. CHLOROMYXIDÆ Thelohan.

Spores with four capsules.

Genus 1. **Chloromyxum** Mingazzini.

With the characters of the family.

Family 3. MYXOBOLIDÆ Thelohan.

Spores with one or two capsules and with an iodinophilous vacuole in the sporoplasm.

Genus 1. **Myxobolus** Butschli.

Spores ovoid, flattened, with one or two capsules. Sporocyst not prolonged into a postcapsular process.

Genus 2. **Henneguya** Thelohan.

Spores ovoid, with one or two median taillike processes at the postcapsular end.

Genus 3. **Hoferellus** Berg.

Spores pyramidal, compressed, with two lateral, taillike processes at the postcapsular end.

The classification here given is unsatisfactory in several respects. In some cases it groups together in the same family species which are obviously not at all closely related. But the most serious fault is its separation of the Myxosporidia into two divisions based on the number of spores formed by a trophozoite. Nothing can be more certain than that this is a relatively unimportant character. Even within the same species we find considerable variation in this respect. According to Auerbach (1910), *Myxidium bergense* is both monosporous and polysporous, and the same is true of a species of *Myxidium* from the gall bladder of *Cottus scorpius*, according to Amerinzew (1911), while *Myxidium incurvatum* is both monosporous and disporous. *Ceratomyxa* has always been looked upon as the very type of the disporous group, and yet *Ceratomyxa recurvata* is both disporous and polysporous.[a] On the other hand, *Ceratomyxa monospora* is both monosporous and disporous. In other genera we find similar examples. *Sinuolinea dimorpha* occurs in two well-defined forms—one disporous, the other polysporous. *Sphærospora polymorpha* and *Chloromyxum granulosum* are also both disporous and polysporous.

The family Myxidiidæ, as defined by Doflein, includes a number of very diverse genera which have few characters in common. Such genera as *Sphærospora* and *Myxidium* are very unlike and should undoubtedly be assigned to different families.

On account of the obviously artificial character of Doflein's classification a new arrangement of the genera has been attempted, which, it is believed, much more nearly expresses their natural relationships. It is fully realized that the classification proposed here can be considered only tentative and no doubt will require considerable modification as knowledge of the group increases. It is, however, hoped that it will serve as a basis for a final classification of the group which will express their real relationships.

The author fully agrees with Amerinzew (1907) on the importance of other characters in addition to the spores, but with the present limited knowledge of the group any system of classification must of necessity be based, primarily, on the spores. Moreover, it is felt that this must always be the case. The plasmodia show few definite characteristics and oftentimes so closely resemble each other as to render it impossible to distinguish between certain species in the absence of the spores. Furthermore, the trophozoites are often very variable and may have a quite different appearance in different hosts.

It will be noticed that the proposed division of the Myxosporidia into two suborders, based on the structure of the spore separates the "free" forms from those which develop only in the tissues. Practically all the tissue parasites are characterized by the flattening of the spore parallel to the transverse plane, which in these forms always coincides with the sutural plane. As previously pointed out, there is good reason to believe that the tissue parasites are more highly specialized and further removed from the primitive forms than are the "free" species. This division, then, represents something more than a purely arbitrary distinction.

The only other important change in Doflein's classification is the rearrangement of the genera formerly included in the Myxidiidæ. It is believed that the proposed arrangement better indicates the relationships of the different genera, although it is felt that there are several inconsistencies here which can only be cleared up with increased knowledge of the group.

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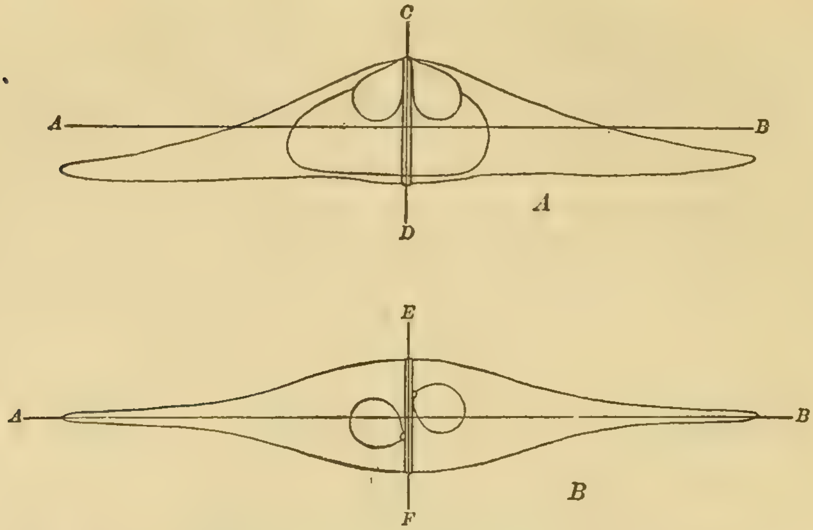
[a] At least two other species of *Ceratomyxa* were found, which, judging from the number of sporoblast cells in the trophozoites, are in all probability polysporous. They are, however, not included in this paper, since only vegetative forms have been available for study.


C
A
B
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D
E
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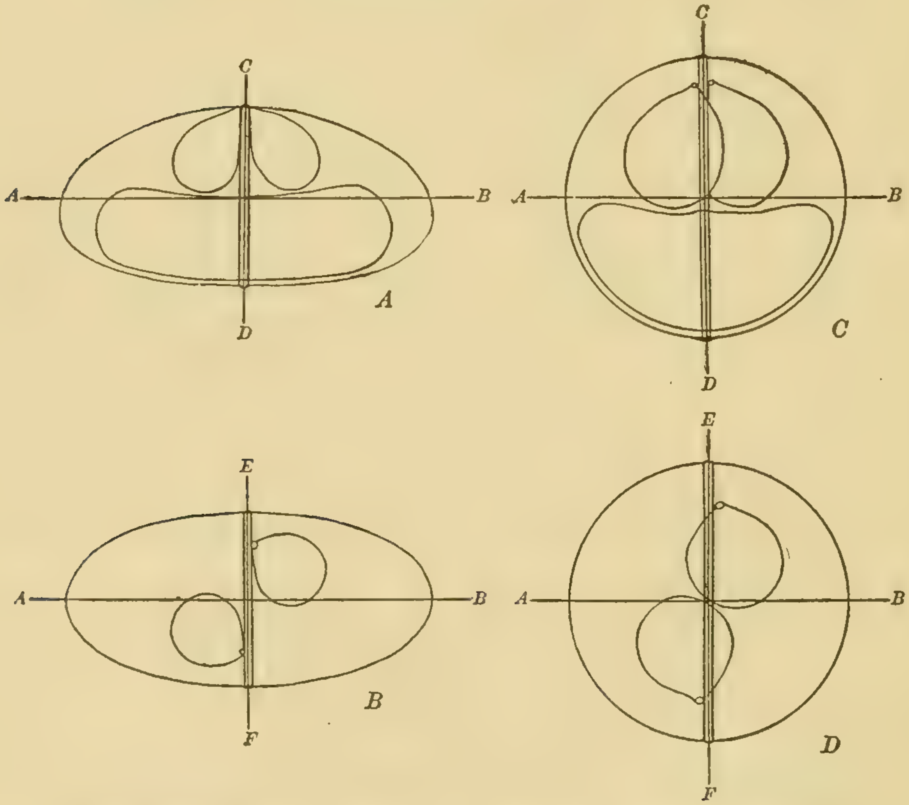
F

FIG. 3.—Spore of *Ceratomyxa*. *A*, from above; *B*, from capsular side; *A-B*, longitudinal axis; *C-D*, transverse axis; *E-F*, vertical axis.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F

FIG. 4.—Spores. *A* and *B*, *Leptotheca*; *C* and *D*, *Sphærospora*. Lettering as in figure 3.

Proposed classification of the Myxosporidia:

Order MYXOSPORIDIA Butschli.

Suborder I. MYXOSPOREA. New suborder.

Spores not compressed parallel to the transverse plane; no iodinophilous vacuole in the sporoplasm. Trophozoites with few exceptions living free in the gall or urinary bladders. Monosporous, disporous, and polysporous.

Family 1. CERATOMYXIDÆ Doflein.

Spores longer than wide; valves rounded or pointed at the ends. Trophozoites usually pyriform. Commonly disporous.

Genus 1. **Leptotheca** Thelohan.

Valves of spore short and rounded. Sutural plane usually slightly oblique to longitudinal axis. Sporoplasm filling most of both valves. (See fig. 4, *A* and *B*.)

Genus 2. **Ceratomyxa** Thelohan.

Valves of spores produced into long, conical, or flattened processes, with rounded or pointed ends. Sutural plane usually perpendicular to transverse axis. Sporoplasm usually unsymmetrically located, extending only a short distance into one valve. (See fig. 3.)

Family 2. SPHÆROSPORIDÆ. New family.

Spores pyramidal or approximately spherical; not distinctly longer than wide; with or without lateral processes.

Genus 1. **Myxoproteus** Doflein.

Spores roughly pyramidal; with or without distinct processes from the base of the pyramid. Disporous.

Genus 2. **Sphærospora** Thelohan.

Spores spherical; without processes of any kind. Capsules distinctly pyriform; convergent when viewed from above (i. e., at right angles to the longitudinal plane). Sutural line forming a straight ridge around spore. (See fig. 4, *C* and *D*.) Disporous and polysporous.

Genus 3. **Sinuolinea,** new genus.

Spores approximately spherical; with or without lateral processes. Capsules rounded, not convergent when seen from above; capsular pores some distance apart, sometimes on nearly opposite sides of the spore. Sutural line forming a prominent ridge, which takes a sinuous course around the spore. Sutural plane usually distinctly twisted on its axis. (See fig. 5, *A* and *B*.) Disporous and polysporous.

Family 3. MYXIDIIDÆ Thelohan.

Spores distinctly elongated along longitudinal axis. Capsules at or near ends of spore and opening in opposite directions. Sutural plane more or less twisted on its axis.

Genus 1. **Myxidium** Butschli.

Spores more or less fusiform, pointed or rounded at ends, not truncated. Capsules may or may not open at ends of spore. (See fig. 5, *C* and *D*.) Monosporous, disporous, and polysporous.

Genus 2. **Sphæromyxa** Thelohan.

Spores fusiform, with truncated ends. Capsules opening at ends of spore. Filaments short and thick, coiled parallel to the longitudinal axis. (See fig. 6, *A* and *B*.) Trophozoites flattened and leaflike. Polysporous.

Genus 3. **Zschokkella** Auerbach.

Spores, when viewed from above, semicircular; pointed at ends. Capsules spherical; situated at ends of spore, but opening on the flattened surface.

Family 4. CHLOROMYXIDÆ Thelohan.

Spores rounded, with four capsules. Polysporous.

Genus 1. **Chloromyxum** Mingazzini.

With the characters of the family.

Suborder II. CYSTOSPOREA. New suborder.

Spores more or less compressed parallel to the transverse plane; usually with two capsules, rarely one. Trophozoites with few exceptions are tissue parasites. Polysporous.

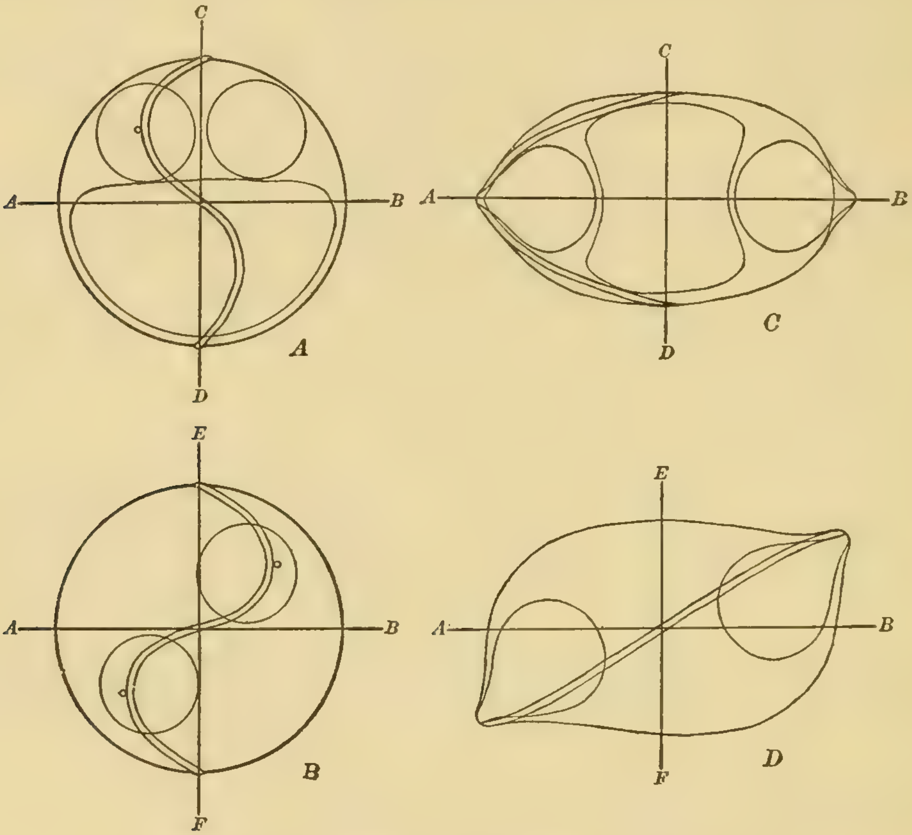

Fig. 5.—Spores. *A* and *B*, *Sinuolinea; C* and *D*, *Myxidium*. Lettering as in figure 3.

Family I. MYXOSOMIDÆ. New family.

Spores without iodinophilous vacuole in the sporoplasm. Two capsules always present.

Genus 1. **Myxosoma** Thelohan.

Spores ovoid, flattened, elongated along transverse axis and pointed at capsular end.

Genus 2. **Lentospora** Plehn.

Spores lenticular, resembling *Myxobolus*, but without iodinophilous vacuole.

Family 2. MYXOBOLIDÆ Thelohan.

Spores with one or two capsules and with an iodinophilous vacuole in the sporoplasm.

Genus 1. **Myxobolus** Butschli.

Spores ovoid, flattened, with one or two capsules. Sporocyst not prolonged into a postcapsular process. (See fig. 6, *C* and *D*.)

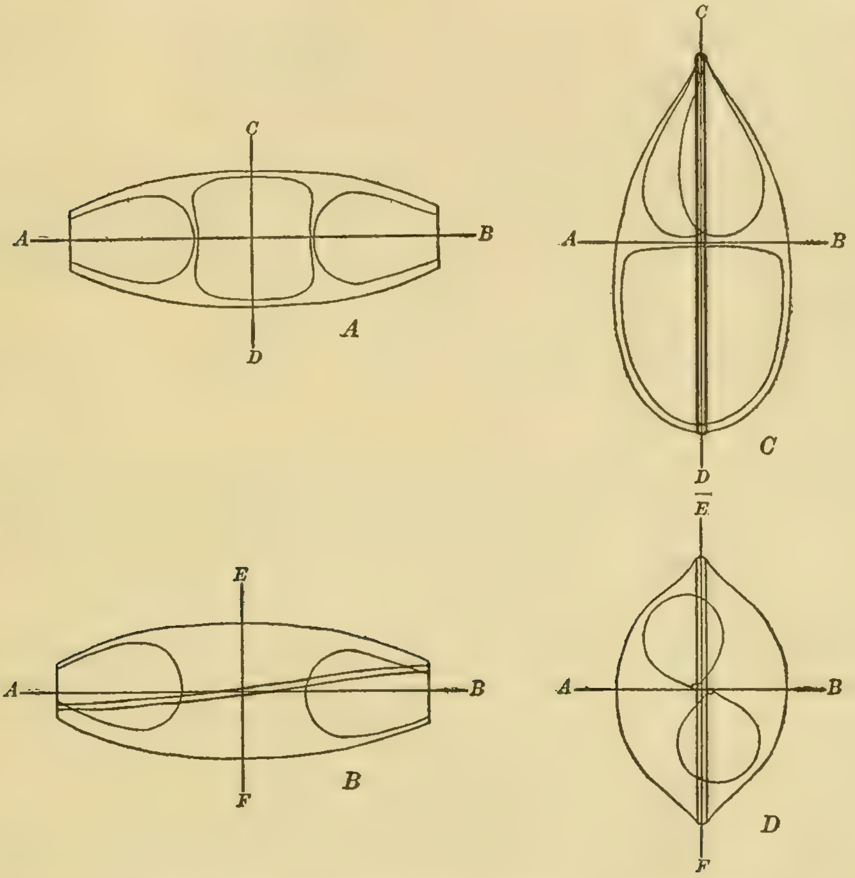

FIG. 6.—Spores. *A* and *B*, *Sphæromyxa*; *C* and *D*, *Myxobolus*. Lettering as in figure 3.

Genus 2. **Henneguya** Thelohan.

Spores ovoid, with one or two median taillike processes at the postcapsular end.

Genus 3. **Hoferellus** Berg.

Spores pyramidal, compressed, with two lateral taillike processes at the postcapsular end.

DESCRIPTION OF SPECIES TAKEN AT BEAUFORT.

Suborder MYXOSPOREA. New suborder.

Family CERATOMYXIDÆ Doflein.

Genus Leptotheca Thelohan.

Leptotheca fusiformis, n. sp. (Pl. XVI, fig. 1–2.)

Trophozoite.—Vegetative trophozoites pyriform, tapering gradually toward the posterior end, which usually terminates in a long, slender process; colorless, transparent. Progressive movements rapid. Endoplasm distinctly granular, the granules being more abundant at the anterior end.

Length of full-grown trophozoites about 50μ, width about 13μ.

Disporous.

Spore.—Elliptical when viewed from above (fig. 1); base of valves circular in cross section but distally are somewhat compressed parallel to the longitudinal plane, so that when viewed from the capsular side the spore appears distinctly fusiform (fig. 2). Sutural plane slightly oblique to longitudinal axis; sutural line forming a distinct ridge. Capsules distinct, located at some distance from the capsular side and opening on opposite sides of the spore. Sporoplasm finely granular; confined to the central part of spore and not extending into the ends of the valves.

Length of spore 16μ, width 9μ; diameter of capsules 4.5μ; length of filament 30μ.

Habitat.—Both vegetative and sporulating trophozoites abundant in the bile of a hammer-head shark, *Cestracion zygæna*, taken July 11, 1914.

Leptotheca scissura, n. sp. (Pl. XVI, fig. 3–8.)

Trophozoite.—Young vegetative trophozoites elongate, with long attenuated posterior process; usually slightly constricted just posterior to rounded anterior end, which bears numerous long, filiform pseudopodia (fig. 3). Progressive movements rapid. Ectoplasm distinguishable only at anterior end, where it gives rise to pseudopodia. Endoplasm usually filled, except in very young individuals, with small, clear, colorless spherules, which are only visable under high magnification. As trophozoites increase in size, spherules become larger and more prominent. Later the spherules become distinctly yellow and contain one to several dark-brown granules, which increase in size and numbers and finally collect in an irregular clump at the center of spherules (fig. 4–6). In some cases the spherules may finally become almost entirely filled with these granules. Size of spherules in same trophozoite uniform but increases as trophozoites grow older. In rare cases the brown granules may be entirely absent even in sporulating trophozites (fig. 7). The spherules are arranged in definite rows, embedded in a clear, homogeneous matrix, giving a very characteristic appearance to the trophozoite. For a short distance at the anterior end spherules are entirely absent, the endoplasm being distinctly granular and containing numerous small fat globules. The larger trophozoites are usually distinctly flattened dorsoventrally. The posterior end may present a characteristic ragged or frayed appearance (fig. 4, 5), due to the endoplasm being drawn out into a number of long, slender processes, which when large enough contain one or more rows of spherules. Occasionally two or more adjacent processes may fuse (fig. 5), so that the posterior region of the trophozoite has the appearance of a network composed of anastomosing strands of protoplasm.

Average length of full-grown trophozoite about 125–150μ, width about 20–25μ. The longest trophozoite observed was 195μ long, with an extreme width of 16μ.

Disporous.

Spore.—Elliptical from above, somewhat flattened along postcapsular side (fig. 8). Sutural line distinct; sutural plane at right angles to longitudinal axis. Capsules and capsulogenous cells distinct, the capsules opening at some distance from the capsular margin. Sporoplasm distinct, finely granular, nearly filling both valves.

Length of spore 22μ, width 11μ; diameter of capsules 4μ.

Habitat.—Abundant in the gall bladders of *Dasybatis hastatus* and *Pteroplatea maclura* during July and August. Lives floating freely in the bile or attached to wall of gall bladder.

Remarks.—The structure of the spherules is very similar to that of *C. sphærulosa* Thelohan, but in other respects this species is very different.

Leptotheca lobosa, n. sp. (Pl. XVI, fig. 9, 10; pl. XVII, fig. 11.)

Trophozoite.—Vegetative trophozoites colorless, transparent to translucent; usually spherical (fig. 9), but may form a large rounded pseudopodium of ectoplasm (fig. 10). Amœboid movements very slow. Ectoplasm remarkable for its coarsely granular structure, the granules being very distinct and of uniform size. In rounded individuals the ectoplasm forms a distinct peripheral layer around the entire trophozoite (fig. 9). Endoplasm less granular and more transparent than extoplasm, containing numerous large, yellow, fat globules, which average larger and are more abundant in large trophozoites. Several denser sporoblast cells can often be indistinctly seen.

Diameter of rounded vegetative trophozoites up to 24μ.

Disporous.

Spore.—Elliptical when viewed from above; valves slightly tapering but rarely exactly alike. Sutural line forming a prominent, sinuous ridge around spore. Capsules and capsulogenous cells distinct; capsules opening at some distance from the capsular margin. Sporoplasm distinct, nearly filling both valves. Even after being freed from the mother trophozoite the postcapsular sides of the spores remain united at the sutural line. This seems to be very characteristic and has been observed in no other species.

Length of spores 16–18μ, width 9–10μ; diameter of capsules 3μ.

Habitat.—Found in the urinary bladder of one individual of *Paralichthys dentatus* taken July 25, 1914.

Remarks.—In its general form the spore approaches that of *Ceratomyxa*, but on the whole seems to show more of the characteristics of *Leptotheca*. The trophozoites exhibit characteristics which are much more common in *Leptotheca* than in *Ceratomyxa*.

Leptotheca glomerosa, n. sp. (Pl. XVII, fig. 12, 13.)

Trophozoite.—Vegetative trophozoites colorless, transparent; rounded or somewhat irregular in shape, with short, lobose pseudopodia. Amœboid movements slow. Ectoplasm forming a distinct, hyaline layer around entire trophozoite. Endoplasm finely granular, with numerous small fat globules varying greatly in size. Almost the entire trophozoite is used up in the formation of the spores (fig. 12) and the ectoplasmic layer is no longer distinguishable.

Diameter of rounded sporulating trophozoites about 11μ.

Disporous.

Spore.—Approximately cylindrical; valves rounded at ends (fig. 13). Capsules distinct. Coiled filaments not visible. Sutural plane at right angles to longitudinal axis. Sporoplasm finely granular and completely filling cavity of sporocyst.

Length of spore 9μ, width 4.5μ; diameter of capsules 2μ.

Habitat.—Occurs occasionally in the urinary bladder of *Paralichthys albiguttus*. Not common.

Genus CERATOMYXA Thelohan.

Ceratomyxa mesospora, n. sp. (Pl. XVII, fig. 14–16.)

Trophozoite.—Vegetative trophozoites colorless, pyriform, elongate, with long, slender posterior process. Numerous filiform pseudopodia at anterior end. Progressive movements rapid. No sharp demarcation between ectoplasm and endoplasm. Endoplasm finely granular and filled with small, colorless, homogeneous spherules (fig. 14). Spherules absent at extreme anterior end, where the endoplasm is denser and more granular. After being on the slide for a short time vegetative trophozoites become rounded and motionless, but on account of the great length of the spores trophozoites containing well-developed spores are unable to contract in this manner.

Length of full-grown trophozoites varies within wide limits according to degree of attenuation. Total length of trophozoites about 70–85μ, length exclusive of posterior process about 50–75μ, width about 20–25μ.

Disporous.

Spore.—Greatly elongate along longitudinal axis, each valve forming a slightly tapering cone more or less rounded at the apex (fig. 15, 16). Valves not compressed. Sutural plane forming an acute angle with longitudinal axis. Capsules conspicuous. Coiled filaments very distinct. Capsules are remarkable in that they are unsymmetrically situated, one capsule being always located in the widest part of the spore, the other being a little to one side (fig. 15). The capsule situated in the middle of spore is usually slightly larger than the other. Sporoplasm unsymmetrically situated, sometimes being entirely confined to the larger valve.

Length of spore 50–65μ, width about 8μ; diameter of capsules 4.5μ; length of filament 90μ.

Habitat.—Both vegetative and sporulating trophozoites abundant in the gall bladder of *Cestracion zygæna* taken July 11, 1914, and in two individuals of *Cestracion tiburo* taken in July.

Remarks.—In many respects this species is similar to *C. sphærulosa* Thelohan, but the spore is much smaller and the sutural plane is not perpendicular to the longitudinal axis as in *sphærulosa* according to Thelohan's figures. According to Thelohan the spherules in *sphærulosa* often contain minute colored granules, but this seems never to be the case in *mesospora.* This species occurs along with *C. recurvata*, new species, but can be easily distinguished by the much smaller size of the spherules.

Ceratomyxa sphairophora, n. sp. (Pl. XVII, fig. 17–21, 23; pl. XVIII, fig. 22.)

Trophozoite.—Vegetative trophozoites colorless, transparent, pyriform, elongate. Numerous fine filiform pseudopodia at anterior end. Progressive movements rapid. Ectoplasm clear, homogeneous, forming a distinct layer at anterior end and often a short distance back along the sides. Structure of endoplasm extremely variable, in majority of trophozoites filled with transparent, homogeneous spherules crowded closely together (fig. 17). These spherules never extend to extreme anterior end, the endoplasm in this region being filled with a closely crowded mass of small fat globules. In other cases the spherules are much less distinct (fig. 18) and sometimes, especially in sporulating individuals, the endoplasm may show only a very indistinct vacuolated structure (fig. 22). Usually, however, even sporulating trophozoites exhibit well-defined spherules. Apparently the indistinctness of the spherules in many cases is due to their becoming less dense until they form more or less distinct polygonal areas separated by a thin layer of granular endoplasm (fig. 18). Another variation is the extreme development of the spherules. In a small percentage of trophozoites the spherules are much larger than usual, sometimes reaching a diameter of 7–8 μ. These large spherules, unlike the smaller, contain numerous minute yellowish or brown granules collected into a mass at the center (fig. 19–20). The spherules or vacuoles, as the case may be, are separated by a thin layer of distinctly granular endoplasm containing numerous rod-shaped or rounded, colorless bodies, which in their appearance are strikingly like small bacteria. That they are, however, not bacteria is shown by the fact that they fail to take the Giemsa stain. Small vegetative trophozoites are usually much like the larger, except that the spherules are not so numerous and there is no distinct mass of fat globules at the anterior end. Occasionally small trophozoites are seen which contain large, clear, irregularly shaped vacuoles varying greatly in size (fig. 21). In the sporulating trophozoites the spores are always situated with the large central portion of the spore at the anterior end, the long attenuated ends of the valves being bent backwards at right angles and extending toward the posterior end of the trophozoite (fig. 22).

Length of sporulating trophozoites about 100–110μ width about 25μ.

Disporous.

Spore.—Valves greatly elongated, tapering gradually toward the ends but abruptly enlarged toward the base (fig. 22, 23). Long, attenuated ends of valves hollow and so fragile that it is almost impossible to find an example in which they are not more or less distorted. As shown in the figures, even after being set free the ends are usually sharply bent toward the postcapsular side a short distance from the sutural plane. Attenuated ends of valves are often twisted or bent in various ways, and there is a marked tendency for the membrane to collapse, especially near the extreme end. Sutural plane perpendicular or only slightly oblique to longitudinal axis. Capsules large, spherical, close together, and slightly convergent, opening some distance apart on the capsular side. Coiled filaments distinct. Sporoplasm confined to large, central part of spores, but extending farther into one valve than the other.

Total length of spore (i. e., from tip to tip of valves along longitudinal axis) 115–140μ, width about 12μ; diameter of capsules 6μ; length of filament 75μ.

Habitat.—Abundant in the gall bladder of the sharp-nosed shark, *Scoliodon terræ-novæ.*

Remarks.—This species appears to be a remarkably variable one. The assumption that the different types of trophozoites described above belong to one and the same species is based on the fact that similar spores have been seen in all the different types, and that all types of trophozoites with intermediate gradations can be found in the same host. It is remarkable that in the case of *C. tænia*, which occurs along with this species, the trophozoites have practically the same structure, even exhibiting the same variations, while the spores are entirely different.

Ceratomyxa tænia, n. sp. (Pl. XVII, fig. 24; pl. XVIII, fig. 25, 26.)

Trophozoite.—Vegetative trophozoites similar to those of *C. sphairophora*, and no character has been found by which they may be distinguished. Spores of this species have been observed in the different types of trophozoites described under *sphairophora*. The sporulating trophozoites, however, can be easily distinguished on account of the very different appearance of the spores and their different arrangement within the trophozoite (fig. 24). The spores of this species are situated, as is usually the case in *Ceratomyxa*, with the greater part of the spore parallel to the long axis of the trophozoite, only a part of one valve being bent back along the rest of the spore.

The sporulating trophozoites are somewhat smaller than in *C. sphairophora*, the average length being about 80μ, average width about 25μ.

Disporous.

Spore.—Very characteristic. Valves greatly elongated; sporocyst very thin, the membrance on opposite sides of each valve being in contact for about two-thirds of its length, forming a thin, ribbonlike structure; basal third of each valve only slightly compressed parallel to the longitudinal plane (fig. 25, 26); terminal ribbonlike portion of each valve usually twisted so that plane of ribbon is at right angles to longitudinal plane. Capsules small, pryiform to spherical, convergent, opening on capsular margin. Coiled filaments indistinct. Sporocyst slightly constricted along sutural line. Sutural plane perpendicular to longitudinal axis. Sporoplasm finely granular, filling the basal third of each valve, usually extending an equal distance into each (fig. 25), but sometimes extending farther into one valve than the other (fig. 26).

Length of spore about 140–150μ; length of central portion about 45μ, width about 6μ; diameter of capsules 3μ.

Habitat.—Found in the gall bladder of *Scoliodon terræ-novæ* along with *C. sphairophora*.

Remarks.—Although the vegetative trophozoites are indistinguishable from *C. sphairophora*, the spores are so different that there seems to be no doubt that it should be regarded as a distinct species. No spores have been observed which could be considered as in any way intermediate between the two.

Ceratomyxa attenuata, n. sp. (Pl. XVIII, fig. 27, 28.)

Trophozoite.—Vegetative trophozoites elongate, pyriform, with long, tapering posterior process; at anterior end numerous long, filiform pseudopodia. Progressive movements rapid. Ectoplasm distinct only at anterior end. Endoplasm filled with small, refractive, yellow or brownish granules, which are uniformly distributed throughout the trophozoite (fig. 27); these granules are always some distance apart and are probably inclosed in very transparent spherules, which can only be distinguished with great difficulty. While no spherules can be made out in many instances, the fact that the granules are always situated at approximately equal distances from each other indicate that they must be inclosed in something of the kind. Between the brownish granules the endoplasm is clear and colorless, not granular, except at extreme anterior end where it contains a clump of small fat globules. In small trophozoites granules are much less abundant and in very small individuals entirely absent.

During development the spores are arranged side by side with their long axes parallel to the long axis of the trophozoite, the valves being bent on themselves near the middle so that the attenuated ends lie along the larger basal portion.

Length of full-grown trophozoites about 100–120μ, width about 27μ. The total length varies greatly, depending on the elongation of the posterior process, which in extreme cases may be drawn out to great length.

Disporous.

Spore.—Valves greatly elongated; unsymmetrical, one valve being about 15μ shorter than the other and ending abruptly; the longer valve tapering gradually to a point (fig. 28). About midway between the ends of each valve (i. e., where they were bent during development) is a thin septum, on the inner side of which the remains of the parietal cell nucleus can sometimes be distinguished; external to the septum the valves are empty, and in the more attenuated valve the walls collapse so that they are in contact along the longitudinal plane. Capsules large and conspicuous, opening on the capsular margin. Coiled filaments distinct. Sutural plane oblique to longitudinal axis; sutural line forming a distinct, sinuous ridge around spore. Sporoplasm distinct, asymmetrically situated in central part of sporocyst.

Length of spore about 115μ, width 9μ; diameter of capsules 4.5μ; length of filament 60μ.

Habitat.—Both vegetative and sporulating trophozoites abundant in the gall bladder of a sharp-nosed shark, *Scoliodon terræ-novæ*, taken July 8, 1915.

Ceratomyxa recurvata, n. sp. (Pl. XVIII, fig. 29–33.)

Trophozoite.—Vegetative trophozoites colorless, pyriform, with long, slender posterior process. Actively motile, forming numerous filiform pseudopodia of ectoplasm at anterior end. Endoplasm filled with large, homogeneous spherules (fig. 29, 31) which average about 10μ in diameter. In some cases spherules are crowded so closely together as to be considerably distorted from original spherical shape. Apparently the density of the spherules may vary considerably in different individuals, since there is great variation in their appearance in stained material. This is especially evident in Giemsa preparations, where in some individuals the spherules are well defined (fig. 30); in others they have so disintegrated in drying as to be practically indistinguishable. This is particularly noticeable in individuals with the largest spherules. Surrounding the spherules is a colorless, distinctly granular endoplasm, the granules being especially abundant at the anterior end, where for a short distance the spherules are absent.

Total length of full-grown trophozoites about 130–175μ, length exclusive of posterior process about 100μ.

Disporous and polysporous; trophozoites containing from 2 to 10 spores observed. Usually more than 2 spores formed, 6 and 8 being the most common numbers observed. It is of interest to note that the number of spores formed is not always an even one, 3, 5, and 7 spores being observed in some cases, indicating that the spores are developed singly from distinct sporoblasts and not necessarily in pairs. Fig. 30 shows a portion of a trophozoite containing 3 distinct sporoblasts and 3 generative cells which doubtless give rise to sporoblasts. Figure 31 also shows a trophozoite containing several sporoblasts, although the individual sporoblasts can not be distinguished in every case.

Spore.—Very characteristic; valves greatly curved toward the postcapsular side (fig. 32), usually symmetrical, but occasionally one may be much more incurved than the other (fig. 33); in some cases the ends may even overlap. Valves circular in cross section at the base but toward the ends greatly flattened parallel to the longitudinal plane the walls of the opposite sides being in contact. Ends of valves sharply pointed. Sutural line distinct. Capsules large and conspicuous, opening at some distance from the capsular margin. Coiled filaments distinct. Sporoplasm distinct, finely granular, usually extending farther into one valve than the other.

Length of spore between points of greatest curvature about 16μ, width 8–9μ; diameter of capsules 4.5μ.

Habitat.—Both vegetative and sporulating trophozoites abundant in the gall bladder of a hammerhead shark, *Cestracion zygæna*, taken July 11, 1914.

Remarks.—In addition to this species the gall bladder contained large numbers of *Leptotheca fusiformis*, n. sp.; *Ceratomyxa mesospora* n. sp.; and *Chloromyxum leydigi* Mingazzini, so that the bile was fairly swarming with Myxosporidia.

Ceratomyxa lunata, n. sp. (Pl. XVIII, fig. 34, 35; pl. XIX, fig. 36, 37.)

Trophozoite.—Vegetative trophozoites pyriform, becoming rounded after being on the slide for a short time. Progressive movements slow. Endoplasm filled with large, homogeneous spherules, which are usually colorless, sometimes light yellow; spherules occasionally inclose several small, brownish granules. At extreme anterior end the endoplasm contains numerous small fat globules.

Disporous.

Spore.—The spores show considerable variation in size and form. The larger and more typical are more or less crescent-shaped; symmetrical; valves distinctly curved toward postcapsular side (fig. 34–36), the curvature often being more marked than in the figure; ends of valves more or less rounded. Sutural plane slightly oblique to longitudinal axis (fig. 37); satural line forming a distinct ridge. Capsules large, distinct, situated a short distance from capsular margin and opening on opposite sides of spore. Coiled filaments distinct. Sporoplasm distinct, finely granular, symmetrically situated, extending an equal distance into each valve and filling entire space around capsules. Smaller spores (fig. 36, 37) differ from larger chiefly in size; the valves are much shortened and have a greater curvature toward the postcapsular side, while the ends are more distinctly rounded.

Length of largest spore observed 38μ, width 9μ; diameter of capsules 4μ; length of filaments 37μ. This was an exceptionally large spore, the average length of the larger spores being about 30μ, the other dimensions being same as given above. Length of smallest spore observed 15μ, width 7μ; diameter capsules 3μ.

Habitat.—Large numbers of vegetative and a few sporulating trophozoites were present in the gall bladder of a tiger shark, *Galeocerda tigrinus*, taken August 8, 1914.

Remarks.—The great variability in the spores was probably due to the fact that they were for the most part formed under abnormal conditions after the trophozoites had been placed on a slide and covered with a cover glass sealed with paraffin. The spores were not studied until 36 hours after being removed from the host, and by that time large numbers of trophozoites had sporulated, although very few spores were present when they were placed on the slide. Spores formed under such conditions are often smaller than those produced under more favorable circumstances.

Ceratomyxa abbreviata, n. sp. (Pl. XIX, fig. 38–41.)

Trophozoite.—Vegetative trophozoites colorless, elongate, pyriform, with usually a very long, slender posterior process (fig. 38, 39). Progressive movements rapid. Ectoplasm abundant, very distinct from endoplasm, thickened at anterior end, and usually forming a distinct layer over entire trophozoite; attenuated posterior process usually composed entirely of ectoplasm, but rarely the endoplasm may extend into it for a short distance; at anterior end the ectoplasm forms short, tapering or filiform pseudopodia. Endoplasm has a very characteristic longitudinally striate appearance; a few small fat globules present at anterior end.

Length of vegetative trophozoites up to about 90μ, width 10–12μ; diameter of rounded sporulating trophozoites about 27μ.

Disporous.

Spore.—Very characteristic. Roughly crescent-shaped; diameter of valves exceptionally great in comparison with their length (fig. 41). Base of valves circular in cross section or slightly compressed parallel to longitudinal plane (fig. 40); ends of valves rounded, slightly unsymmetrical. Sporocyst exceptionally tough and resistant to reagents. Capsules large, prominent, located at some distance from capsular side and opening on opposite sides of spore midway between capsular and postcapsular margins. Sporoplasm distinct, finely granular, confined entirely to one valve.

Length of spore 17μ, width 14μ; diameter of capsules 4.5μ.

Habitat.—Found in the gall bladder of a sharp-nosed shark, *Scoliodon terræ-novæ,* taken August 2, 1912. Although a number of these sharks have been examined, this is the only time this species has been found.

Ceratomyxa flagellifera, n. sp. (Pl. XIX, fig. 42, 43.)

Trophozoite.—Vegetative trophozoites colorless, short, pyriform, tapering rapidly toward the posterior end (fig. 43). In some cases the posterior end may be divided into a number of long, slender, transparent processes. The anterior end bears large numbers of extremely long, filiform pseudopodia, which can be seen to sweep slowly back like a whiplash until they come to lie by the side of the body, sometimes extending some distance beyond the posterior end. Progressive movements slow. Ectoplasm clear, transparent, forming a distinct layer at anterior end, which gives rise to the pseudopodia and often extends for some distance along the sides. Endoplasm has a very peculiar structure; in large trophozoites filled with large numbers of rod-shaped, bacterialike bodies, which usually lie with their long axes parallel to the long axis of the trophozoite. These bodies are much more abundant in the anterior half of the trophozoite, gradually decreasing in number toward the posterior end, which is very transparent, its limits being often very difficult to make out. In smaller trophozoites the bacterialike bodies are much less numerous and may be entirely absent, the endoplasm then showing a distinctly vacuolated structure. In the larger trophozoites there can usually be seen one to several rounded bodies composed of clear, transparent, protoplasm containing a few small, refringent granules (fig. 43).

Length of vegetative trophozoites up to about 115–120μ; width about 40–45μ.

Disporous.

Spore.—Valves greatly elongated, conical, with rounded ends (fig. 42). Sutural line forming a prominent ridge around spore. Capsules large, conspicuous, opening on opposite sides of spore at some distance from capsular margin. Coiled filaments very distinct. Sporoplasm distinct, granular, symmetrically situated, but extending only a short distance into each valve.

Length of spore 118μ, width 12μ; diameter of capsules 6μ.

Habitat.—Found in the gall bladder of a shark, *Carcharhinus* sp?, taken July 27, 1911.

Remarks.—The rounded protoplasmic bodies which occur in the larger trophozoites are probably gemmules. They appear strikingly like the gemmules of *Sinuolinea dimorpha.* (See Davis, 1916.) In a number of cases these bodies were seen to escape from the mother trophozoite, breaking through near the posterior end, where the outer covering appears to be much weakened. I have considerable evidence that this method of reproduction is not rare in *Ceratomyxa.*

Ceratomyxa agglomerata, n. sp. (Pl. XIX, fig. 44, 45.)

Trophozoite.—Vegetative trophozoites colorless, transparent, pyriform, usually with long, slender, posterior process (fig. 44). Actively motile, moving by means of characteristic wavelike movements of the ectoplasm, from which are projected numerous short, conical to filiform pseudopodia. The pseudopodia travel back along sides of body for about one-third its length and then disappear, new ones being continually formed at the anterior end. Ectoplasm, distinguishable only at anterior end, where it forms a distinct layer extending back along the sides for a short distance. Endoplasm clear, very transparent, usually homogeneous, sometimes finely granular. In some cases homogeneous spherules can be indistinctly seen in the endoplasm. Large numbers of fat globules usually present, which are for the most part collected into one to several clumps in a characteristic manner (fig. 44).

Length of sporulating trophozoites about 38μ, width about 12μ.

Disporous.

Spore.—Asymmetrical, one valve being somewhat smaller and more attenuated than the other (fig. 45); larger valve compressed parallel to longitudinal plane. In some instances the difference between the valves is not as great as figured. Capsules spherical. Coiled filaments indistinct. Sporoplasm filling nearly entire smaller valve, but only extending a short distance into the larger.

Length of spore 24–28μ, width 5μ; diameter of capsules 3μ.

Habitat.—Abundant in the gall bladder of *Synodus fœtans*. Nearly all the fish of this species taken in the harbor, except in the case of very young individuals, were found to be infected.

Ceratomyxa amorpha, n. sp. (Pl. XIX, fig. 46, 47.)

Trophozoite.—Vegetative trophozoites colorless, rounded or irregular in shape, with short, lobose pseudopodia (fig. 46); not pyriform; slowly amœboid. Ectoplasm well developed, forming a distinct layer around entire trophozoite; transparent, finely granular. Endoplasm granular, with large numbers of small fat globules scattered through it or aggregated into one or two large clumps, not collected into a number of small clumps as in *C. agglomerata* which occurs in the same host.

Disporous.

Spore.—Asymmetrical; crescent-shaped; valves short, conical, somewhat compressed parallel to longitudinal plane; one valve distinctly smaller and more conical than the other (fig. 47). Sutural plane perpendicular to longitudinal axis; sutural line distinct. Capsules large, conspicuous, opening at some distance from the capsular side. Coiled filaments distinct. Sporoplasm distinctly granular, unsymmetrically situated, being chiefly confined to smaller valve.

Length of spore 27μ, width 11μ; diameter of capsules 4μ.

Habitat.—Occurs in the gall bladder of *Synodus fœtans*.

Remarks.—This species has been found only in fish collected outside the inlet and was present in two out of three fish examined. A number of these fish collected inside the harbor have been examined, but in no case did they show any traces of this species, although *C. agglomerata* were abundant. This would seem to indicate that the lizardfish from outside rarely enter the harbor.

Ceratomyxa monospora, n. sp. (Pl. XIX, fig. 48–51; pl. XX, fig. 52–57.)

Trophozoite.—Vegetative trophozoites colorless, very transparent, pyriform, usually with a short slender posterior process and one to several filiform pseudopodia at the anterior end (fig. 48–50). Trophozoites usually become rounded and motionless a short time after being removed to the slide. Progressive movements very slow. Ectoplasm not clearly distinguished from endoplasm, the entire trophozoite being composed of a clear, finely granular protoplasm. Larger trophozoites contain numerous small fat globules, which are usually aggregated into small clumps (fig. 48); fat globules much less abundant in small individuals (fig. 49). In some cases after having been on the slide for a short time small, homogeneous, spherical bodies could with difficulty be distinguished in the endoplasm. They were not observed in trophozoites which had just been removed from the host and are possibly to be regarded as the result of degenerative changes.

Length of vegetative trophozoites up to about 24μ, width up to about 15μ. Monosporous trophozoites much smaller than disporous.

Monosporous and disporous. Monosporous trophozoites are considerably more abundant than the disporous. The spores are relatively large, nearly the entire substance of the trophozoite being used up in their formation (fig. 51–54).

Spore.—Crescent-shaped; valves cylindrical, tapering gradually toward the end, which is rounded and compressed parallel to longitudinal plane (fig. 55–57); valves show considerable variation in amount of curvature (cf., fig. 52, 55, 56). Spores usually slightly asymmetrical, one valve being more attenuated than the other; in rare cases the valves may be practically alike. Sutural plane perpendicular to longitudinal axis. Capsules large and distinct. Sporoplasm usually unsymmetrically situated.

Length of spore 18–25μ, width 5–6μ; diameter of capsules 3μ.

Habitat.—Very abundant in the gall bladder of *Peprilus alepidotus.* Is usually present in large numbers during June, being absent in only 5 out of 17 fish examined during this month. In July the parasites were much less frequently met with. Only 3 out of 6 fishes examined during the first week in July were infected, and later in the month nearly every fish examined showed no trace of this parasites. It is interesting to note that during June only vegetative trophozoites were found in a number of fishes, while in July the great majority were in late stages of sporulation and no case was found where only vegetative trophozoites were present.

This species also occurs in the gall bladder of *Prionotus evolans.* Both trophozoites and spores are somewhat larger in *P. evolans* than in *P. alepidotus*, but in other respects there is very little difference.

Remarks.—This species is evidently very close to C. *pallida* Thelohan, but unfortunately his description is very incomplete. According to Thelohan the trophozoites of *pallida* are rounded, with short, lobed pseudopodia, and he makes no mention of the presence of fat globules, which are characteristic for *monospora.* Thelohan was also uncertain as to whether *pallida* is monosporous. It has, therefore, seemed best to consider the species distinct, at least provisionally.

Ceratomyxa streptospora, n. sp. (Pl. xx, fig. 58–60.)

Trophozoite.—Vegetative trophozoites colorless, transparent, pyriform; a few conical, filiform, and wavelike pseudopodia at anterior end (fig. 58). Ectoplasm distinguishable only at anterior end, where it forms a clear, transparent layer. Endoplasm finely granular; filled with transparent, homogeneous spherules, which show only indistinctly; a few small, fat globules usually present but never abundant.

Measurements of full-grown vegetative and sporulating trophozoites vary from 48μ long by 12μ wide to 60μ long by 9μ wide.

Disporous.

Spore.—Valves greatly elongated, compressed parallel to longitudinal plane, ends rounded (fig. 59). Valves usually somewhat twisted on the longitudinal axis, so that the spores appear unsymmetrical (fig. 60), due to the valves being viewed at different angles to the plane of flattening. Sutural line forming a distinct ridge. Capsules large, spherical. Coiled filament not distinguishable. Sporoplasm finely granular, entirely filling both valves.

Length of spore 34–39μ, width 4μ; diameter of capsules 3μ.

Habitat.—Common in the gall bladder of *Chætodipterus faber.* Large numbers were found in 8 out of 9 fishes examined June 9–17. None were found in 4 fishes examined July 11–13. Very few trophozoites were found floating freely in the bile, most of them being attached to the epithelium.

Ceratomyxa aggregata, n. sp. (Pl. xx, fig. 61–64.)

Trophozoite.—Vegetative trophozoites colorless, transparent, rounded to somewhat irregular in shape, rarely pyriform; slowly amœboid. Ectoplasm not distinct from endoplasm. Endoplasm finely granular, containing numbers of small fat globules, which are usually aggregated into irregular clumps. Sporulating trophozoites move very slowly if at all; show a marked tendency to collect in groups composed of a large number of individuals so closely associated that it is often impossible to make out the limits of individual trophozoites. During development the distal half of each valve is so closely applied to the postcapsular side of the proximal half as to be indistinguishable in the living trophozoite (fig. 62).

Length of sporulating trophozoites about 18μ, width about 14μ.

Disporous.

Spore.—Crescent-shaped; valves much elongated, tapering gradually toward the ends, which are strongly compressed parallel to longitudinal plane, the opposite walls often being in contact (fig. 63, 64). Capsules large, approximately spherical, opaque, opening close together on the capsular side. Sporoplasm distinctly granular, usually symmetrically situated.

Length of spore about 50μ, width 6–7μ; diameter capsules 3.5μ.

Habitat.—Common in the gall bladder of *Leiostomus xanthurus.* Present in 14 out of 18 individuals examined during July.

Also occurs in the gall bladder of *Micropogon undulatus.*

Ceratomyxa undulata, n. sp. (Pl. xx, fig. 65, 66.)

Trophozoite.—Vegetative trophozoites colorless, pyriform, sometimes fusiform, tapering rapidly toward posterior end (fig. 65). Progressive movements rapid. Ectoplasm distinct at anterior end and extending along the sides from one-third to one-half distance to posterior end, gradually growing thinner until it entirely disappears. Ectoplasm constantly undergoing rapid, wavelike undulating movements and extruding fine conical or filiform pseudopodia. Pseudopodia form very rapidly and vary greatly in length. After reaching a considerable length the pseudopodia usually travel posteriorly along sides of body for some distance and then disappear. Endoplasm very transparent, often indistinctly vacuolated; containing numerous small fat globules distributed at random. Sporulating trophozoites usually fusiform, sometimes pyriform.

Average length of full-grown trophozoites about 25μ, width 10–12μ.

Disporous.

Spore.—Crescent-shaped, slightly asymmetrical, one valve being somewhat longer and more conical than the other; valves cylindrical, not compressed, ends rounded (fig. 66). Capsules convergent, opening on capsular side. Coiled filaments distinct. Sporoplasm distinctly granular, unsymmetrically situated, sometimes being almost confined to more conical valve; in such cases the other valve collapses so that walls of opposite sides are in contact.

Length of spore 22–24μ, width about 6μ; diameter capsules 3μ.

Habitat.—Common in the gall bladder of *Ancylopsetta quadrocellata* during June, July, and August.

Ceratomyxa navicularia, n. sp. (Pl. xx, fig. 67–70.)

Trophozoite.—Vegetative trophozoites colorless, rounded or slightly irregular in shape, never pyriform. Very slowly amœboid. No distinct ectoplasm. Entire trophozoite finely granular; a few small fat globules present. Nearly entire trophozoite is used up in the formation of spores (fig. 67).

Diameter of sporulating trophozoite about 17μ.

Disporous.

Spore.—Shows considerable variation in shape and size. Symmetrical or asymmetrical, often boat-shaped, slightly compressed parallel to longitudinal plane, ends of valves rounded. Capsules small, convergent, opening on capsular side. Coiled filaments very indistinct. Sporoplasm finely granular, extending into both valves, but usually somewhat farther into one than the other.

Average length of spore about 16μ; extreme variations observed 14–22μ; average width about 6μ; extreme variations observed 5–7.5μ; diameter of capsules 2μ.

Habitat.—Not uncommon in the urinary bladder of *Paralichthys dentatus* and *P. albiguttus* during June, July, and August. Also found in the urinary bladder of *Sphæroides maculatus* taken August 2, 1915.

Ceratomyxa spinosa, n. sp. (Pl. xx, fig. 71; pl. xxi, fig. 72.)

Trophozoite.—Vegetative trophozoites colorless, transparent, rounded or slightly irregular in shape, with short, lobose pseudopodia; slowly amœboid. Ectoplasm forming a distinct hyaline layer around entire trophozoite. Endoplasm indistinctly granular, with numerous small fat globules. During development ends of spores are folded along postcapsular side (fig. 71).

Monosporous and disporous.

Spore.—Very characteristic. Central portion greatly enlarged; ovoid, with very long tapering processes extending out from each end (fig. 72). Sutural plane perpendicular to longitudinal axis. Capsules large and conspicuous; spherical, opening at some distance from capsular margin. Coiled filaments indistinct. Sporoplasm finely granular, chiefly located in one valve, extending into the other only a short distance beyond the capsule.

Length of spore about 80μ; length of enlarged central portion about 13μ; width 7μ; diameter of capsules 4μ.

Habitat.—Found in the urinary bladder of *Paralichthys albiguttus*. Rare.

Family SPHÆROSPORIDÆ, new family.

Genus Myxoproteus Doflein.

Myxoproteus cordiformis, n. sp. (Pl. XX, fig. 73; pl. XXI, fig. 74–80.)

Trophozoite.—Vegetative trophozoites colorless, transparent, rounded; very slowly amœboid, usually forming a single, short, lobose pseudopodium (fig. 74–76). Ectoplasm not distinct. Entire trophozoite finely granular, with a few fat globules. In rare cases may show an indistinct vacuolar structure, and occasionally small individuals are found with a single large, central vacuole (fig. 76).

Diameter of rounded sporulating trophozoites about 18μ.

Disporous.

Spore.—Heart-shaped when seen from above, with peculiar winglike expansions on each side which contain remains of parietal cells (fig. 78–80). Sutural plane oblique to longitudinal axis (fig. 80). Capsules opening at some distance from capsular margin. Capsulogenous cells distinct. Sporoplasm finely granular, entirely filling cavity of sporocyst not occupied by capsulogenous cells.

Length of spore 12μ, width 10–11μ, thickness 6μ; diameter of capsules 3–4μ.

Habitat.—Common in the urinary bladder of *Chætodipterus faber;* usually attached to the epithelial lining (fig. 77). The parasites were found in all 12 fishes examined during June and July.

Myxoproteus cornutus, n. sp. (Pl. XXI, fig. 81–85.)

Trophozoite.—Vegetative trophozoites, usually somewhat elongated or irregular in shape, with short lobose pseudopodia (fig. 81–83); slowly amœboid, quickly becoming contracted and motionless (fig. 84) after being placed on the slide. Ectoplasm well developed, hyaline; in rounded individuals forming a distinct layer around entire trophozoite (fig. 83, 84). When moving, entire ectoplasm may flow into pseudopodia (fig. 81). Endoplasm opaque, crowded with coarse, refringent granules varying in shape, and with usually a few fat globules. In contracted resting condition endoplasm becomes more opaque, with granules crowded more closely together, while the ectoplasm is more abundant (fig. 84). This is apparently due to the granules becoming more concentrated into a central mass, the surrounding hyaline portion being squeezed out to form the very conspicuous ectoplasmic layer.

Diameter of rounded trophozoites up to 27μ.

Disporous.

Spore.—Heart-shaped, with two very characteristic processes projecting from the capsular side (fig. 85). Sporocyst relatively thick. Capsules large and conspicuous, opening some distance apart. Coiled filaments distinct. Sporoplasm finely granular, with a few small fat globules; entirely filling cavity of sporocyst not occupied by capsules and capsulogenous cells.

Length of spore 12μ; width exclusive of capsular processes 9μ; length of capsular processes about 5μ; diameter of capsules 3μ.

Habitat.—Common in the urinary bladder of *Bairdiella chrysura.* Vegetative trophozoites abundant during June and July, but only a few sporulating trophozoites and free spores observed.

Genus Sphærospora Thelohan.

Sphærospora polymorpha, n. sp. (Pl. XXI, fig. 86–92; pl. XXII, fig. 93, 94.)

Trophozoite.—Colorless, usually somewhat elongate (fig. 90), but never very irreguar in shape; slowly amœboid. After being on the slide for a short time become rounded and motionless (fig. 86–89). Ectoplasm distinct around younger trophozoites, hyaline, forming one to several large lobate pseudopodia, which in turn extrude several short, conical pseudopodia (fig. 88). In larger trophozoites ectoplasm often not distinguishable except at ends of pseudopodia, which in such cases are composed chiefly of endoplasm. Endoplasm distinctly granular, sometimes vacuolated in smaller trophozoites (fig. 88), but in larger individuals vacuoles are indistinct or absent; small fat globules usually abundant, especially in larger individuals; numbers of rounded sporoblast cells can be distinctly seen.

Dimensions of large vegetative trophozoites about 35 by 50μ.

Disporous and polysporous. Polysporous trophozoites rarely contain many spores at the same time.

Spore.—Spherical, sometimes slightly compressed parallel to longitudinal plane. Sutural line forming a distinct ridge around spore in the plane of the capsules (fig. 91, 92); on each side are a number of concentric striations extending around each valve parallel to the sutural line. Capsules large, distinctly pyriform. Coiled filaments indistinct. Sporoplasm distinct, finely granular.

Diameter of spores 7–10μ, averaging about 8μ; capsules 2–2.5μ by 4–5μ.

Habitat.—Common in the urinary bladder of *Opsaus tau*. Found in 9 out of 11 fishes examined during June and July. Both vegetative and sporulating trophozoites were abundant.

Remarks.—The trophozoites are usually attached to the urinary epithelium, which in badly infected fish may be almost entirely covered with them. The younger trophozoites are attached to the free ends of the epithelial cells (fig. 93), which, however, show no signs of injury. As the trophozoites increase in size they come to lie in depressions formed by the destruction of the ends of epithelial cells (fig. 94). Often the injury to the epithelial cells is carried much farther than shown in the figure, in some cases the part of the cell immediately surrounding the nucleus being all that is left, but even in such cases the nucleus shows little signs of injury. In the larger trophozoites the basal portion becomes specially modified to form an organ of attachment. The protoplasm in sections appears much more densely granular in this region than elsewhere and stains more deeply with plasma stains. Sometimes the organ is drawn out into long processes which extend in between the epithelial cells.

Genus **Sinuolinea**, new genus.

Sinuolinea dimorpha (Davis.) (Pl. XXII, fig. 95–100.)

Sphærospora dimorpha Davis 1916.

Trophozoite.—Occurs in two very distinct forms, one disporous, the other polysporous.

Vegetative disporous trophozoites colorless, transparent, irregular in shape (fig. 95); progressing by slow amœboid movements. When attached to the epithelium of the urinary bladder they are usually rounded with one to several pseudopodia extending in between the free ends of the epithelial cells. Ectoplasm distinct, forming a homogeneous hyaline layer around entire trophozoite. Endoplasm filled with indistinct vacuoles separated by a denser homogeneous protoplasm similar to the ectoplasm in appearance. Endoplasm usually contains a few small fat globules, which are more abundant in older individuals. Occasionally the endoplasm contains one or more erythrocytes.

Average diameter of full-grown disporous trophozoites about 25–30μ.

The polysporous trophozoites have a very characteristic appearance and can be readily distinguished from the disporous form in all but the youngest stages. When attached to the urinary epithelium the free end of the body is drawn out into a long, cylindrical, taillike process (fig. 97). The body, except where attached to the epithelium, is covered with numerous short, hairlike ectoplasmic processes, which are longer and more abundant toward the free end. While not movable, these processes are readily absorbed and reformed. The trophozoites are attached to the epithelium by means of a specially modified part of the ectoplasm, which forms irregular, thin, platelike processes extending in between the outer ends of the epithelial cells. Owing to the viscid character of the ectoplasm, the trophozoites are often completely covered with extraneous particles of various kinds. After being placed on the slide the specially modified ectoplasm at the larger end gives rise to numerous conical or arborescent pseudopodia, by means of which the trophozoite progresses slowly, the enlarged basal part of the body becoming the anterior end. Pseudopodia are at first composed entirely of ectoplasm, but later as they increase in size the endoplasm may extend into the proximal portion. In extreme cases after being on the slide for some time almost the entire substance of the trophozoite may flow into the large branched pseudopodia (fig. 98). Endoplasm distinctly granular and usually more or less vacuolated; numerous small fat globules usually present and are often very abundant in enlarged basal or anterior part of body (fig. 96). In addition to fat globules, small, irregular, refractive granules and occasionally a few yellowish crystals (probably hematoidin) can be seen in the endoplasm. These crystals are never abundant and are entirely lacking in the majority of trophozoites. Endoplasm also sometimes contains erythrocytes in various stages of disintegration. Very often several comparatively large, rounded bodies can be plainly seen in the endoplasm. These are the gemmules, and each is composed of an outer hyaline layer surrounding a finely granular central portion containing numerous refractive granules.

The size of polysporous trophozoites varies within wide limits. The largest trophozoite measured was 575μ long with a maximum diameter of 90μ.

Spore.—Approximately spherical. Sutural line forming a prominent sinuous ridge around spore (fig. 99, 100). Capsules nearly spherical, large, conspicuous. Sporoplasm forming a distinct, rounded, granular mass.

Diameter of spore about 15μ; diameter of capsules 4.5μ; length of filaments 27–35μ.

Habitat.—Both disporous and polysporous forms abundant in the urinary bladder and ureters of *Cynoscion regalis.* Every one of a large number of fishes examined was found to be infected. In some individuals the polysporous forms were relatively rare, in others they were equally if not more abundant than the disporous.

Remarks.—For a detailed account of the structure and development of this species the reader is referred to a previous paper by the writer. (See Davis, 1916.)

Sinuolinea capsularis, n. sp. (Pl. XXII, fig. 101, 102; pl. XXIII, fig. 103–107.)

Trophozoites.—Vegetative trophozoites colorless or light yellow, rounded to very irregular in shape (fig. 101–103). Progressing by slow amœboid movements. When first removed from the host are usually rounded, but after being placed on the slide soon become very irregular in shape, due to the formation of numerous large branched or arborescent pseudopodia formed entirely of ectoplasm Ectoplasm transparent, usually distinctly granular (sometimes homogeneous in younger trophozoites), merging gradually with the endoplasm. Often in rounded trophozoites no distinct ectoplasmic layer can be made out (fig. 102). Endoplasm differs from ectoplasm chiefly in the presence of large numbers of fat globules. In large trophozoites the endoplasm often contains one to several relatively large, rounded bodies which are sharply differentiated from the surrounding protoplasm (fig. 102, 103). These bodies are in all probability gemmules similar to those formed by *S. dimorpha.* They are more finely granular and more transparent than the surrounding protoplasm and are practically identical with the small, free trophozoites shown in figure 104, which are very abundant. Trophozoites containing several gemmules are usually rounded and motionless and appear to be more or less degenerate. Many such trophozoites were observed to disintegrate, thus liberating the gemmules. Whether the gemmules in this species are only liberated through the disintegration of the mother trophozoite was not decided. Sporulating trophozoites were rare and were never seen to contain gemmules.

Diameter of rounded vegetative trophozoites up to 40μ.

Disporous; possibly also polysporous. No sporulating trophozoites with more than two spores were observed, but many vegetative trophozoites were considerably larger than those containing spores, the latter measuring only about 27μ in diameter.

Spore.—Approximately spherical, sometimes slightly elongated along longitudinal axis (fig. 105–107). Sutural plane much twisted on its axis; sutural line forming a prominent ridge around spore. Capsules and capsulogenous cells large and conspicuous, occupying more than one-half cavity of sporcyst. Coiled filaments distinct. Sporoplasm distinct, granular, with numerous small fat globules. As is often the case in this genus, the spores are easily distorted by mechanical and osmotic pressure, and may then appear quite different from the normal form.

Diameter of spore 12–14μ, diameter of capsules 4.5μ, length of filament 50μ.

Habitat.—Common in the urinary bladder of *Paralichthys albiguttus.* Also found in the urinary bladder of *Paralichthys dentatus* and *Spheroides maculatus.* In all cases the vegetative trophozoites were abundant. Only a few sporulating trophozoites and free spores were observed and in most instances were entirely absent. Nine individuals of *P. albiguttus* were examined during July and August, of which eight were infected with this species, but in only one of the eight were sporulating trophozoites and spores found, and then only in small numbers. Most of the larger trophozoites contained gem, mules, and apparently this is the common method of reproduction at this season.

Sinuolinea arborescens, n. sp. (Pl. XXIII, fig. 108–110.)

Trophozoite.—Vegetative trophozoites colorless to light yellow; rounded to very irregular in shape; actively amœboid, forming large arborescent pseudopodia of ectoplasm (fig. 108). Ectoplasm well developed, very distinct, hyaline, homogeneous. Endoplasm coarsely granular, sometimes containing a few fat globules; several denser sporoblast cells can usually be distinguished. Older trophozoites are less active and the ectoplasm is less distinct. In sporulating trophozoites the ectoplasm may entirely disappear, the entire trophozoite consisting of a coarsely granular mass.

Diameter of rounded sporulating trophozoites about 75μ.

Polysporous.

Spore.—Rounded, slightly elongated along longitudinal axis (fig. 109, 110). Capsules large and conspicuous, opening a short distance apart on the capsular side. Sutural line forming a prominent ridge, which makes a characteristic S-shaped turn on the capsular side (fig. 110). Coiled filaments very distinct.

Length of spore 15μ, width 12μ, diameter capsules, 5μ.

Habitat.—Common in the urinary bladder of *Siphostoma floridæ.*

Sinuolinea opacita, n. sp. (Pl. XXIII, fig. 111, 112.)

Trophozoite.—Vegetative trophozoites colorless, opaque; rounded or slightly irregular in shape; slowly amœboid, forming a number of short, lobose pseudopodia (fig. 111). Ectoplasm not distinct, except around ends of pseudopodia, where it forms a thin, hyaline layer. Endoplasm opaque, finely granular, with numerous greenish-yellow fat globules varying greatly in size.

Diameter of rounded sporulating trophozoites about 22μ. Several exceptionally large trophozoites were seen with a diameter of about 100μ.

Disporous.

Spore.—Nearly spherical, with flattened, lateral appendages extending from the postcapsular side of each valve (fig. 112). Sutural plane slightly twisted on its axis; sutural line forming a prominent sinuous ridge around spore. Capsules large, opening at some distance from the capsular margin. Coiled filaments distinct. Capsulogenous cells large and easily distinguishable. Sporoplasm distinct, finely granular, containing several comparatively large fat globules.

Diameter of spores about 12–13μ, diameter of capsules 4μ.

Habitat.—Occurs in the urinary bladder of *Paralichthys albiguttus.* Found in only one fish taken August 4, 1914. Both vegetative and sporulating trophozoites were abundant.

Sinuolinea brachiophora, n. sp. (Pl. XXIII, fig. 113.)

Trophozoite.—Colorless; rounded to somewhat irregular in shape. Ectoplasm distinct, hyaline. Endoplasm granular, with numerous large fat globules. Spores arranged in the trophozoites with their postcapsular sides in contact and the armlike processes mutually interlocking.

Disporous.

Spore.—Presents a remarkable appearance. Central portion approximately spherical, with long, lateral, armlike appendages extending from each valve (fig. 113). These appendages are empty except at extreme distal ends, which contains a granular mass, probably the remains of the parietal cell. Sutural plane slightly oblique to longitudinal axis, not distinctly twisted on its axis, sutural line forming a prominent ridge around spore. Capsules large, conspicuous, opening at some distance from capsular margin; capsulogenous cells exceptionally large and distinct, the nuclei being plainly visible by the sides of the capsules. Capsulogenous cells and capsules occupying more than one-half cavity of sporocyst. Sporoplasm distinct, finely granular.

Length of spore exclusive of appendages 9–11μ, length of appendages 18–22μ, width of spore about 9μ, diameter of capsules 3.5μ.

Habitat.—Lives in the urinary bladder of *Paralichthys albiguttus.* Found only in one fish taken August 13, 1914. Vegetative trophozoites were abundant, but only a few spores were found.

Remarks.—Possibly this species should be made the type of a new genus, but the spore undoubtedly more closely resembles that of *Sinuolinea* than any other genus. In many respects this species is very similar to *S. opacita,* which occurs in the same host.

Family MYXIDIIDÆ Thelohan.

Genus **Myxidium** Butschli.

Myxidium incurvatum Thelohan. (Pl. XXIII, fig. 114–118; pl. XXIV, fig. 119–121.)

Myxidium incurvatum Thelohan, 1895, p. 341.

Trophozoite.—Vegetative trophozoites colorless, translucent, rounded to somewhat irregular in shape, with usually a single short, lobose pseudopodium of ectoplasm, which may extrude short conical or filiform pseudopodia along its margin (fig. 114, 115). Occasionally the pseudopodium may be drawn out into a long, slender process (fig. 117). In some cases after being on the slide for some time the trophozoites contract into a rounded mass covered with large numbers of short, hairlike pseudopodia. Ectoplasm clear, transparent, distinguishable only in the pseudopodia. Endoplasm distinctly, sometimes coarsely, granular, with a few comparatively large, greenish-yellow fat globules; usually several rounded, denser sporoblast cells can be distinctly seen. After having been on the slide for some time the endoplasm may be fairly riddled with large, clear vacuoles (fig. 117). The surface of the trophozoites is distinctly viscid, and it is common to find several individuals clinging closely together in an irregular mass, in which it is impossible to distinguish the outlines of individual trophozoites.

Diameter of rounded disporous trophozoites about 13–15μ, of monosporous about 10–11μ.

Monosporous and disporous, the majority being disporous.

Spore.—Cylindrical, valves rounded at ends (fig. 119–121). Capsules large, opening on each side of spore at right angles to the longitudinal plane. Sutural line can be faintly seen extending around spore just inside the capsular pores. Filaments when extruded in HCl remained tightly coiled

Length of spore 8–9μ, width 5–6μ; diameter of capsules about 3μ.

Habitat.—Common in the gall bladder of *Fundulus majalis*, *Gambusia affinis*, and *Mugil cephalus*. Found in 5 out of 16 adult *F. majalis* taken July 9 and 10.

Remarks.—Although the shape of the spore differs somewhat from Thelohan's figure, the difference is hardly sufficient to justify considering it specifically distinct. This species has a remarkably wide range of hosts. Thelohan has reported it from the gall bladder of *Nerophis æquoreus*, *Sygnathus acus*, *Callionymus lyra*, *Blennius pholis*, *Trachinus draco*, and *Scorpæna scrofa*.

Myxidium glutinosum, n. sp. (Pl. XXIV, fig. 122–124.)

Trophozoite.—Vegetative trophozoites colorless, elongated or somewhat irregular in shape; slowly amœboid, moving by means of a broad, lobose pseudopodium of hyaline ectoplasm (fig. 122). Ectoplasm not distinct except in pseudopodium. Endoplasm finely granular, with a number of rounded homogeneous spherules, which vary greatly in size and can be only indistinctly seen. The mature spores while still within the mother trophozoites are surrounded by a clear, refractive gelatinous envelope. This envelope only appears as the spore matures, and its absence around one spore in figure 123 is probably due to the fact that one spore matures a little before the other. A similar difference in the rate of development of the spores has been observed in other species.

Diameter of rounded sporulating trophozoites about 20μ.

Disporous.

Spore.—Cylindrical, ends of valves rounded except at one side, where the capsules open at the apex of a small, conical elevation (fig. 124). Spore characterized by the presence of a transparent, homogeneous gelatinous envelope, which under the microscope has the appearance of a bright ring or halo. This envelope is distinctly viscid, and small particles can often be seen adhering to it. Capsule large, distinctly pyriform, opening on each side nearly at right angles to the longitudinal plane.

Length of spore 10–11μ, width 6μ; diameter of capsules 3μ.

Habitat.—Not uncommon in the gall bladder of *Cynoscion regalis*.

Myxidium phyllium, n. sp. (Pl. XXIV, fig. 125–127.)

Trophozoite.—Exceptionally large; flattened, leaflike, usually folded on itself; motionless, no signs of pseudopodia observed (fig. 125). Ectoplasm forming a distinct transparent layer around entire trophozoite. After being on slide for some time ectoplasm usually becomes covered with very numerous, short, indistinct, hairlike processes, which are not present when first removed from the host. Endoplasm finely granular, with numerous fat globules, not vacuolated.

Diameter of trophozoites up to 1.35 mm.

Polysporous.

Spore.—Fusiform, slightly truncated at each end where capsules open (fig. 126). Sporocyst with numerous longitudinal ridges. Capsules large, opening at ends of spore. Sporoplasm finely granular, with several small fat globules.

Length of spore 11μ, width 8μ; diameter of capsules 3μ.

Habitat.—Occurs in the gall bladder of *Gambusia affinis*. Only one trophozoite was found in each fish. A small percentage only of fish were infected, and in every case the infected fish were partly grown individuals about 2.5 cm. long.

Remarks.—This species has been found only in fish collected in one locality and was the only species found in these fish. Numbers of *Gambusia* from other localities have been examined and a considerable percentage found to be infected with *M. incurvatum* but never with *phyllium*.

Genus **Sphæromyxa** Thelohan.

Sphæromyxa balbianii Thelohan. (Pl. XXIV, fig. 128–131.)

Sphæromyxa balbianii, Thelohan, 1895, p. 342.
Sphæromyxa balbianii, Gurley, 1894, p. 282.

Trophozoite.—Small vegetative trophozoites colorless; slowly amœboid; surrounded by a homogeneous, hyaline layer of ectoplasm (fig. 128) from which arise short, lobose pseudopodia. In some instances when moving in the same direction for some time the ectoplasm may accumulate at the (temporarily) anterior end (fig. 129), the advancing edge of the ectoplasm forming small, conical pseudopodia, which are rapidly retracted and new ones formed in their place. Endoplasm not as transparent as ectoplasm, vacuolated, the vacuoles in some cases being very distinct, in others barely distinguishable. Endoplasm between the vacuoles distinctly granular. As trophozoites increase in size, vacuolated structure becomes more evident, the endoplasm often having the appearance of a foam or emulsion, as is well represented by Thelohan (1895, pl. VIII, fig. 55). The large sporulating trophozoites present a very different appearance. They are flattened, leaflike, with a very irregular contour and usually distinctly yellow, although large sporulating trophozoites were seen which were perfectly colorless. In medium-sized trophozoites the ectoplasm forms a transparent layer around the entire trophozoite, but in larger individuals ectoplasm becomes thinner until it can be distinguished only at the ends of the rounded, pseudopodialike projections. Larger trophozoites are often filled with spores arranged in pairs inclosed in a common membrane, as described by Schröder (1907) for *S. sabrazesi*. Such trophozoites often lose the characteristic vacuolated and granular structure and appear hyaline throughout. This is probably due to degenerative changes preparatory to the disintegration of the trophozoite. The trophozoites vary greatly in size and shape, the largest trophozoite measured having an extreme diameter of 900μ.

Polysporous.

Spore.—Fusiform, ends strongly truncated. Sporocyst comparatively thick and impervious to reagents; usually showing on its outer surface indistinct, parallel, longitudinal striations (fig. 130). Capsules large. Coiled filaments distinct, short, thick with rounded ends (fig. 131). Sporoplasm granular, the two nuclei distinctly visible as clear vacuolarlike structures.

Length of spore 17–20μ, width 5–6μ; length of filament 20μ.

Habitat.—Common in the gall bladder of *Siphostoma floridæ* and *S. louisianæ*. A large number of fishes were examined during June, July, and August and were all found to be infected. Usually the parasites were folded together in a mass which sometimes almost filled the gall bladder.

Remarks.—Both spores and trophozoites differ in some minor respects from Thelohan's description, the trophozoites being much more irregular and the spores larger, while the longitudinal striations are very faint or entirely absent.

Genus **Zschokkella** Auerbach.

Zschokkella globulosa, n. sp. (Pl. XXIV, fig. 132–135.)

Trophozoite.—Colorless, transparent; rounded; slowly amœboid, forming short, lobose pseudopodia (fig. 132, 134). Ectoplasm not distinct, trophozoites being distinctly granular throughout. Characterized by the presence of several large fat globules.

Diameter of rounded sporulating trophozoites about 15–16μ.

Monosporous and disporous.

Spore.—Capsular side flattened; postcapsular side rounded (fig. 134, 135). Sutural plane twisted on its axis and oblique to longitudinal axis; sutural line forming a distinct, sinuous ridge around spore. Capsules located at ends of spore and opening on capsular side. Sporoplasm finely granular, very transparent.

Length of spore 11μ, width 7μ; diameter of capsules 3μ.

Habitat.—Found in the urinary bladder of *Spheroides maculatus* taken August 2, 1915. Both vegetative trophozoites and spores were abundant.

Family CHLOROMYXIDÆ Thelohan.

Genus **Chloromyxum** Mingazzini.

Chloromyxum leydigi Mingazzini.

Chloromyxum leydigi, Mingazzini, 1890, p. 160.
Chloromyxum leydigi, and *C. incisum*, Gurley, 1893, p. 259.
Chloromyxum leydigi and *C. incisum*, Thelohan, 1895, p. 345.
Chloromyxum leydigi, Doflein, 1898, p. 160.
Chloromyxum leydigi, Erdmann, 1911.

This species is very widely distributed among elasmobranchs. It was found in the gall bladder of the following species: *Dasybatis hastatus*, *Dasybatis sabina*, *Pteroplatea maclura*, *Socliodon terræ-novæ*, *Cestracion zygæna*, *Cestracion tiburo*, and *Carcharhinus limbatus*. Trophozoites were present in practically every individual of these species examined except in very young sharks. Both vegetative and sporulating trophozoites were abundant. "Gregarinoid forms" similar to those described by Mingazzini and others were common.

Chloromyxum granulosum, n. sp. (Pl. XXIV, fig. 136-138.)

Trophozoite.—Colorless to light yellow; elongated when first placed on the slide (fig. 136) but soon became contracted and motionless; progressing by very slow amœboid movements. Ectoplasm usually not distinguishable, but in a few cases trophozoites were noticed which had formed one or two short, lobose pseudopodia of hyaline ectoplasm.

After having been on the slide for some time rounded trophozoites often became surrounded by a distinct ectoplasmic layer. Entire trophozoite usually distinctly and coarsely granular, the granules varying greatly in size and shape (fig. 136); sometimes indistinctly vacuolated. A few small fat globules present in younger trophozoites becoming more abundant with age.

Diameter of rounded polysporous trophozoites about 30μ.

Disporous and polysporous.

Spore.—Approximately spherical, with four distinct ridges on post-capsular half of each valve converging toward the capsular side (fig. 137, 138.) Sutural line forming a distinct ridge. Capsules distinctly pyriform, convergent.

Diameter of spore 7μ, diameter of capsules 2μ.

Habitat.—Common in the urinary bladder of *Tylosurus marinus* during July and August.

Remarks.—There is an interesting variation in the appearance of trophozoites from different fishes. In some fishes all were colorless, while in others the larger trophozoites were distinctly yellow.

Family MYXOBOLIDÆ Thelohan.

Genus **Myxobolus** Butschli.

Myxobolus capsulatus, n. sp. (Pl. XXIV, fig. 139.)

Trophozoite.—Very irregular in shape; distributed through connective tissues in state of "diffuse infiltration."

Polysporous.

Spore.—Distinctly pyriform, strongly compressed parallel to sutural plane. Characterized by exceptionally large pyriform capsules (fig. 139), which fill almost the entire cavity of sporocyst. Sporoplasm relatively small, limited to extreme postcapsular end of spore. Iodinophilous vacuole visible in living spore.

Length of spore (i. e., along longitudinal axis) 10-11μ, width (along transverse axis) 16μ, capsules 4μ wide by 11μ long, length of filament 84μ.

Habitat.—Not uncommon in the visceral connective tissues of *Cyprinodon variegatus.*

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EXPLANATION OF PLATES.

All figures were drawn with the aid of the Abbe camera lucida at the level of the base of the microscope. Unless otherwise specified, all figures were drawn from living material.

PLATE XVI.

Leptotheca fusiformis.

FIG. 1. Spore from above. × 1,500.
FIG. 2. Spore from capsular side. × 1,500.

Leptotheca scissura.

FIG. 3. Young trophozoite. × 700.
FIG. 4, 5. Large vegetative trophozoites in which spherules are well developed. × 700.
FIG. 6. Portion of trophozoite more highly magnified to show structure of spherules. × 1,500.
FIG. 7. Sporulating trophozoite. × 700.
FIG. 8. Spore from above. × 1,500.

Leptotheca lobosa.

FIG. 9. Contracted vegetative trophozoite. × 1,500.
FIG. 10. Vegetative trophozoite with large pseudopodium of ectoplasm. × 1,500.

PLATE XVII.

FIG. 11. *Leptotheca lobosa.* Spores still united at the sutural line. × 1,500.

Leptotheca glomerosa.

FIG. 12. Sporulating trophozoite. × 1,500.
FIG. 13. Spore from above. × 1,500.

Ceratomyxa mesospora.

FIG. 14. Trophozoite drawn from Giemsa smear. × 1,500.
FIG. 15. Spore from above. × 1,500.
FIG. 16. Spore from the capsular side. × 1,500.

Ceratomyxa sphairophora.

FIG. 17–19. Vegetative trophozoites. × 700.
FIG. 20. Portion of trophozoite showing structure of spherules. × 1,500.
FIG. 21. Young vegetative trophozoite. × 700.
FIG. 23. Spore from above. × 950.

Ceratomyxa taenia.

FIG. 24. Sporulating trophozoite. × 700.

PLATE XVIII.

Ceratomyxa sphairophora.

FIG. 22. Sporulating trophozoite. × 700.

Ceratomyxa taenia.

FIG. 25, 26. Spores from above. × 700.

Ceratomyxa attenuata.

FIG. 27. Vegetative trophozoite. × 700.
FIG. 28. Spore from above. × 950.

Ceratomyxa recurvata.

FIG. 29. Vegetative trophozoite. Drawn from a wet smear fixed in formol-corrosive-acetic and stained with acid hemalum. × 950.
FIG. 30. Portion of trophozoite showing several generative cells and sporoblasts. Drawn from a wet smear stained with iron hematoxylin. × 1,500.
FIG. 31. Large trophozoite showing several generative cells and sporoblasts. Drawn from a Giemsa smear. × 950.
FIG. 32, 33. Spores from above. × 1,500.

Ceratomyxa lunata.

FIG. 34, 35. Spores from above. × 1,500.

PLATE XIX.

Ceratomyxa lunata.

FIG. 36. Spore from above. × 1,500.
FIG. 37. Spore from capsular side. × 1,500.

Ceratomyxa abbreviata.

FIG. 38. Vegetative trophozoite. × 700.
FIG. 39. Vegetative trophozoite containing two generative cells and one vegetative nucleus. Drawn from a wet smear stained with iron hematoxylin. × 1,500.
FIG. 40. Two spores viewed from the end. × 640.
FIG. 41. Spore from above. × 1,500.

Ceratomyxa flagellifera.

FIG. 42. Spore from above. × 750.
FIG. 43. Vegetative trophozoite. × 400.

Ceratomyxa agglomerata.

FIG. 44. Vegetative trophozoite. × 1,500.
FIG. 45. Spore from above. × 1,500.

Ceratomyxa amorpha.

FIG. 46. Vegetative trophozoite. × 700.
FIG. 47. Spore from above. × 1,500.

Ceratomyxa monospora.

FIG. 48. Vegetative trophozoite. × 1,500.
FIG. 49. Vegetative trophozoite. Drawn from unstained specimen killed in osmic vapor. × 1,500.
FIG. 50. Vegetative trophozoite in which two sporoblasts can be faintly seen. × 1,500.
FIG. 51. Disporous sporulating trophozoite. × 1,500.

PLATE XX.

Ceratomyxa monospora.

FIG. 52–54. Monosporous sporulating trophozoites. × 1,500.
FIG. 55. Spore from above. From the gall bladder of *P. alepidotus*. × 1,500.
FIG. 56, 57. Spores form the gall bladder of *P. evolans*. × 1,500.

Ceratomyxa streptospora.

FIG. 58. Sporulating trophozoite. × 640.
FIG. 59, 60. Spores from above. × 1,400.

Ceratomyxa aggregata.

FIG. 61. Small vegetative trophozoite. × 1,500.
FIG. 62. Sporulating trophozoite. × 1,500.
FIG. 63. Spore from above. × 1,400.
FIG. 64. Spore with filaments extruded. × 1,400.

Ceratomyxa undulata.

FIG. 65. Vegetative trophozoite. × 1,500.
FIG. 66. Spore from above. × 1,500.

Ceratomyxa navicularia

FIG. 67. Sporulating trophozoite. × 1,400.
FIG. 68–70. Spores from above. × 1,500.

Ceratomyxa spinosa.

FIG. 71. Monosporous sporulating trophozoite. × 1,500.

Myxoproteus cordiformis.

FIG. 73. Vegetative trophozoite. × 1,500.

PLATE XXI.

Ceratomyxa spinosa.

FIG. 72. Spore from sporulating trophozoite (fig. 71). × 1,500.

Myxoproteus cordiformis.

FIG. 74–76. Vegetative trophozoites. × 1,500.
FIG. 77. Trophozoite attached to epithelium of urinary bladder. Drawn from a section stained with iron hematoxylin. × 1,500.
FIG. 78. Spore from one end. × 1,500.
FIG. 79. Spore from above. × 1,500.
FIG. 80. Spore from capsular side. × 1,500.

Myxoproteus cornutus.

FIG. 81–84. Vegetative trophozoites. × 1,500.
FIG. 85. Spore from above. × 1,400.

Sphærospora polymorpha.

FIG. 86. Disporous vegetative trophozoite. × 1,500.
FIG. 87. Disporous sporulating trophozoite. × 1,500.
FIG. 88. Polysporous sporulating trophozoite containing only two spores. × 1,300.
FIG. 89. Polysporous sporulating trophozoite. × 700.
FIG. 90. Vegetative trophozoite containing a large number of nuclei. Drawn from a Giemsa smear. × 1,500.
FIG. 91. Spore viewed at right angles to the sutural plane. × 1,500.
FIG. 92. Spore viewed at right angles to figure 91. × 1,500.

PLATE XXII.

Sphærospora polymorpha.

FIG. 93, 94. Vegetative trophozoites attached to epithelium of urinary bladder. Drawn from a section. × 800.

Sinuolinea dimorpha.

FIG. 95. Vegetative disporous trophozoite. × 1,500.
FIG. 96. Vegetative polysporous trophozoite. × 640.
FIG. 97. Vegetative polysporous trophozoite attached to epithelium of urinary bladder. Internal structure not shown. × 640.
FIG. 98. Vegetative polysporous trophozoite some time after being placed on the slide. × 640.
FIG. 99. Spore slightly compressed under the cover glass. The entire course of the sutural line is shown. × 1,400.
FIG. 100. Mature spore. × 1,400.

Sinuolinea capsularis.

FIG. 101. Vegetative trophozoite showing characteristic pseudopodia. × 700.
FIG. 102. Contracted trophozoite containing several rounded bodies, probably gemmules. × 700.

PLATE XXIII.

Sinuolinea capsularis.

FIG. 103. Large vegetative trophozoite. × 700.
FIG. 104. Small vegetative trophozoite. × 700.
FIG. 105–107. Different views of spores. × 1,500.

Sinuolinea arborescens.

FIG. 108. Large vegetative trophozoite. × 640.
FIG. 109. Spore from above. × 1,500.
FIG. 110. Spore from capsular side. Internal structure not shown. × 1,500.

Sinuolinea opacita.

FIG. 111. Vegetative trophozoite. × 1,500.
FIG. 112. Spore from above. × 1,500.

Sinuolinea brachiophora.

FIG. 113. Spore from above. × 1,500.

Myxidium incurvatum.

FIG. 114–117. Vegetative trophozoites. × 1,500.
FIG. 118. Monosporus sporulating trophozoite. × 1,500.

PLATE XXIV.

Myxidium incurvatum.

FIG. 119, 120. Two views of spore at right angles to each other. × 1,500.
FIG. 121. Spore drawn from a Giemsa smear. All the nuclei are shown. × 1,500.

Myxidium glutinosum.

FIG. 122. Vegetative trophozoite. × 1,400.
FIG. 123. Sporulating trophozoite. × 1,400.
FIG. 124. Spore. × 1,400.

Myxidium phyllium.

FIG. 125. Trophozoite just removed from gall bladder. Internal structure not shown. × 33.
FIG. 126. Spore. ×1,400.
FIG. 127. Spore drawn from Giemsa smear. The parietal nuclei are not visible. × 2,000.

Sphæromyxa balbianii.

FIG. 128, 129. Small vegetative trophozoites. × 640.
FIG. 130. Spore. × 2,100.
FIG. 131. Spore with filaments extruded. × 1,400.

Zschokkella globulosa.

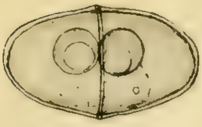
FIG. 132. Vegetative trophozoite. × 1,500.
FIG. 133. Sporulating trophozoite. × 1,500.
FIG. 134. Spore from above. × 1,500.
FIG. 135. Spore from postcapsular side. × 1,500.

Chloromyxum granulosum.

FIG. 136. Trophozoite containing only a few spores. × 720.
FIG. 137. Spore. × 1,500.
FIG. 138. Spore from capsular side. × 1,500.

Myxobolus capsulatus.

FIG. 139. Spore viewed at right angles to sutural plane. × 1,500.



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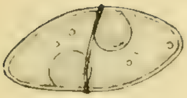

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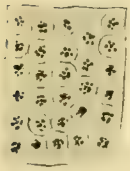

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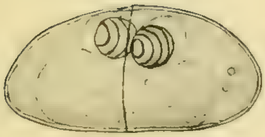

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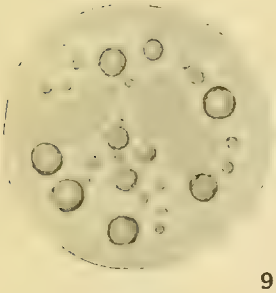

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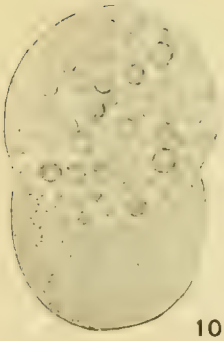

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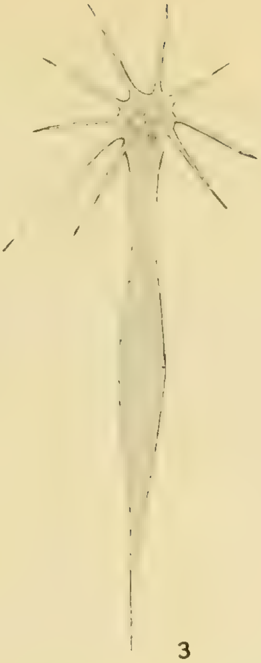

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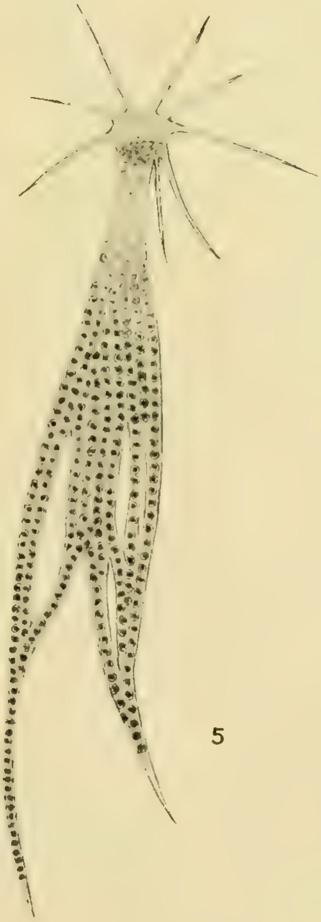

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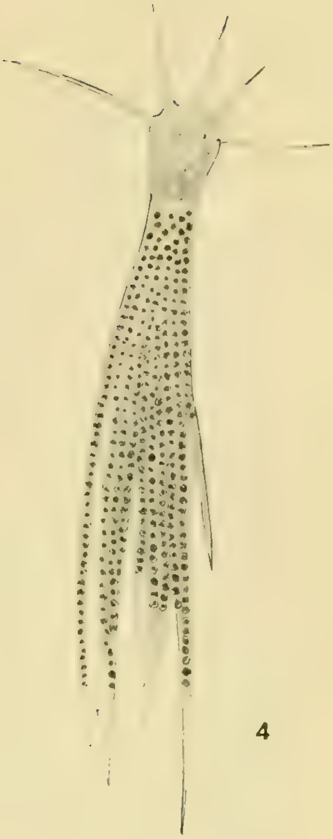

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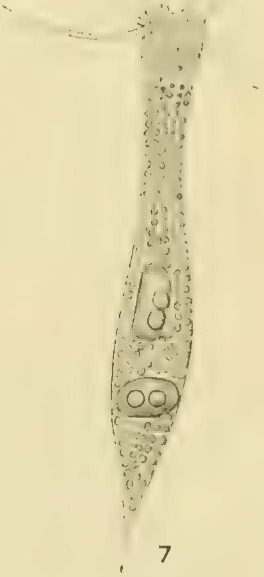

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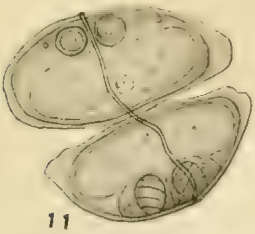
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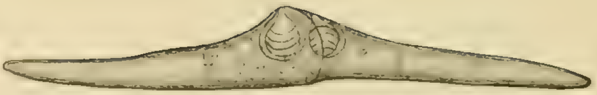
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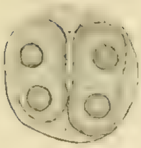
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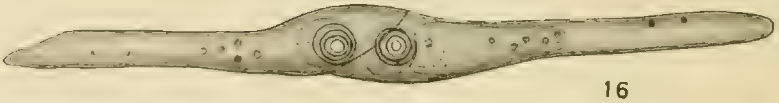
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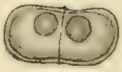
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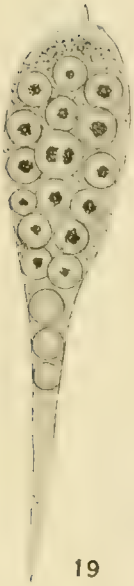
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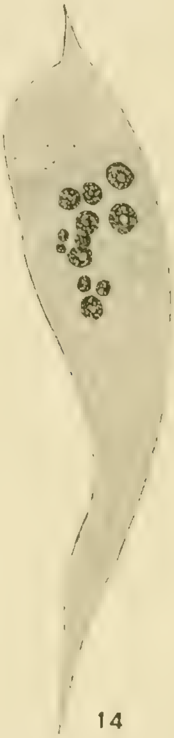
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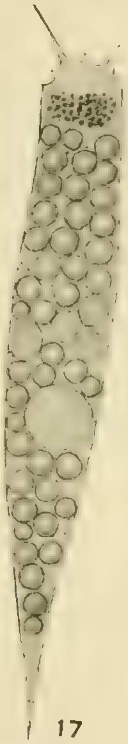
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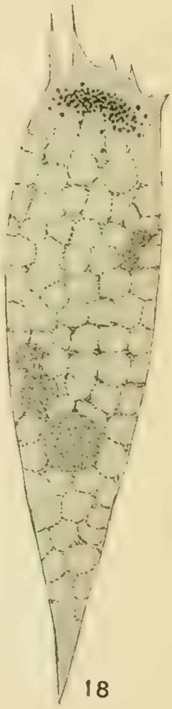
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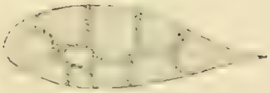
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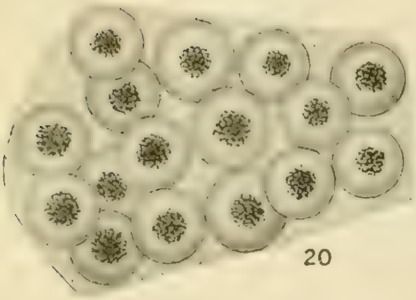
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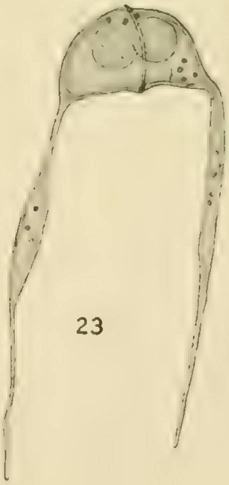
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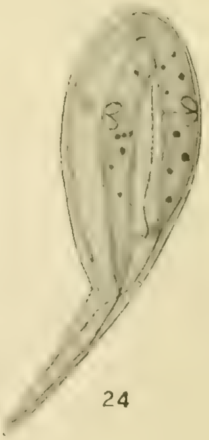
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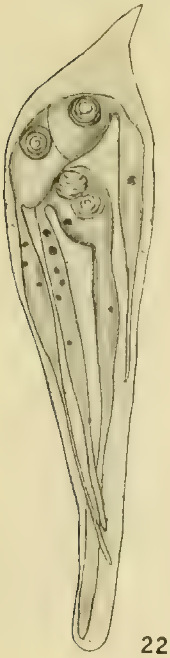
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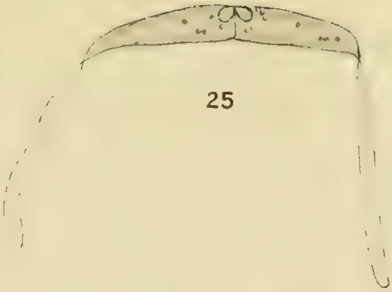
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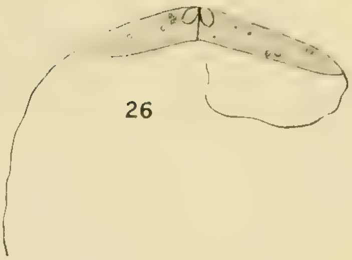
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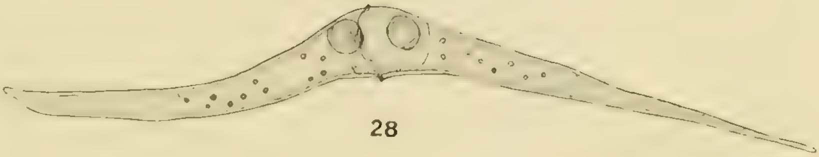
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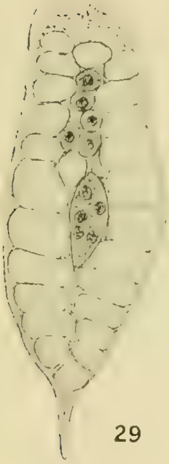
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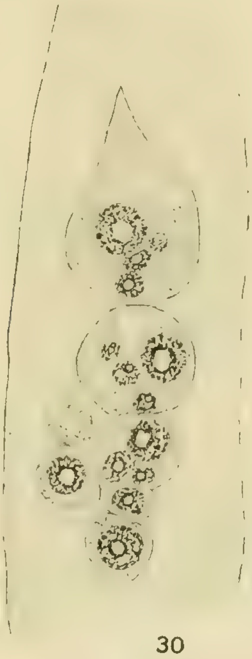
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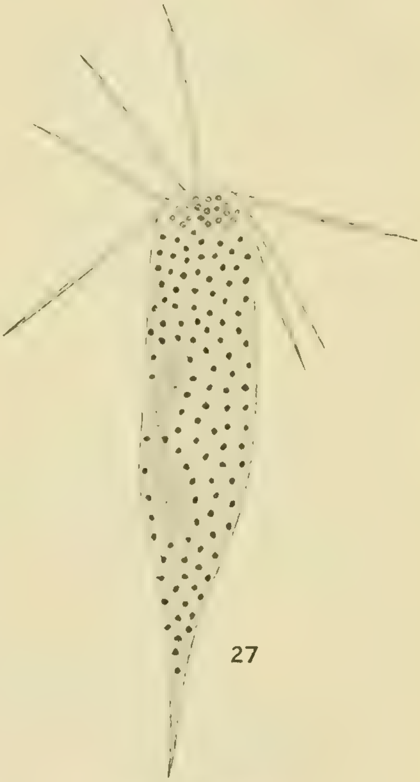
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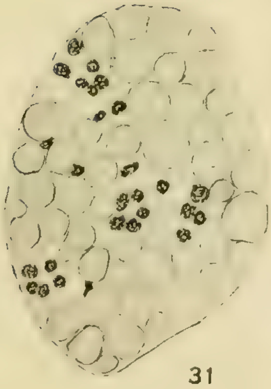
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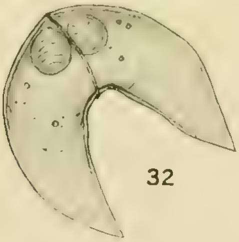
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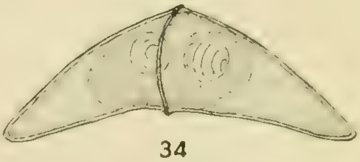
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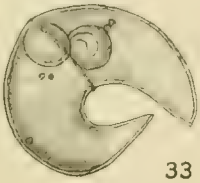
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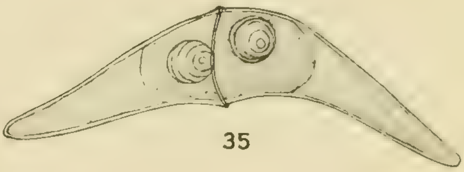
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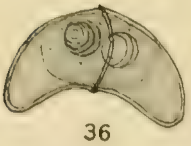
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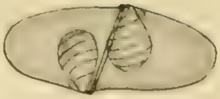
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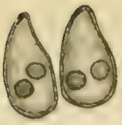
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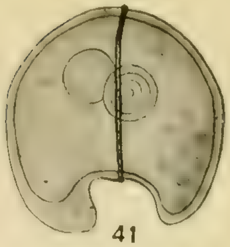
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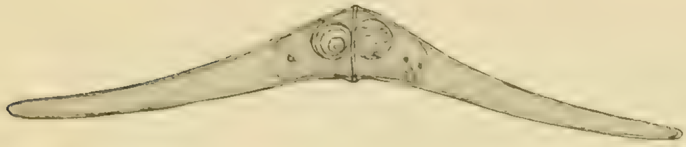
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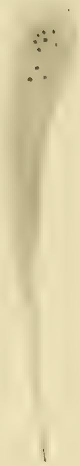
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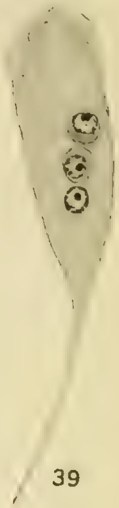
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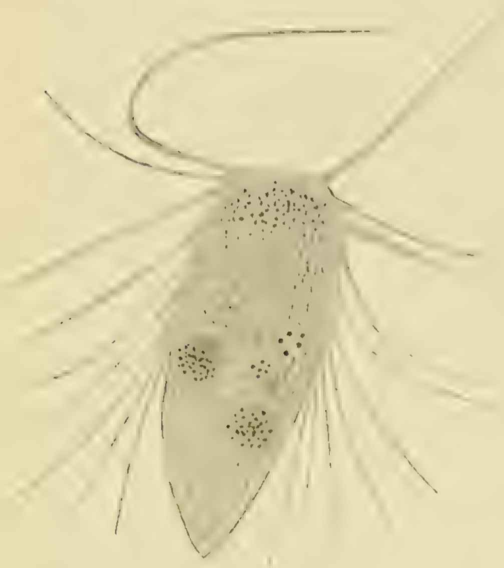
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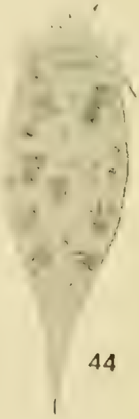
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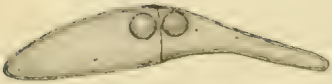
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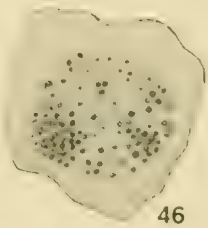
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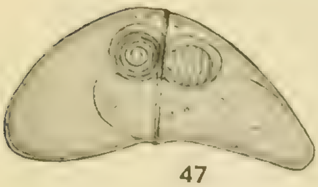
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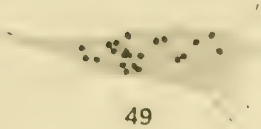
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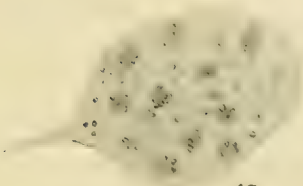
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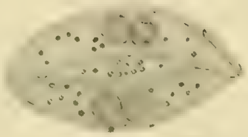
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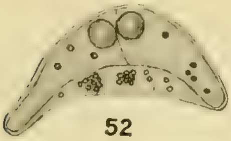
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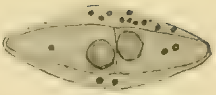
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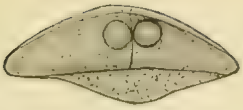
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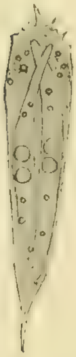
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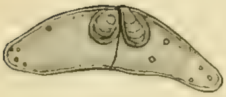
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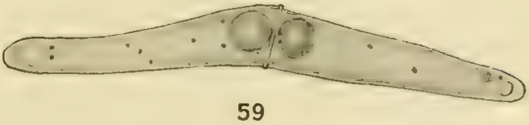
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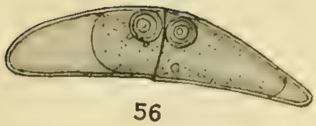
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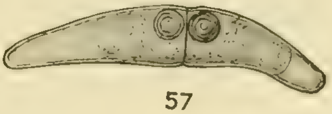
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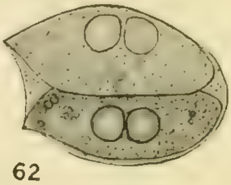
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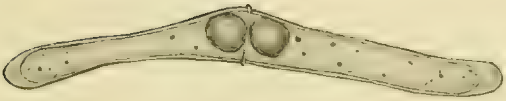
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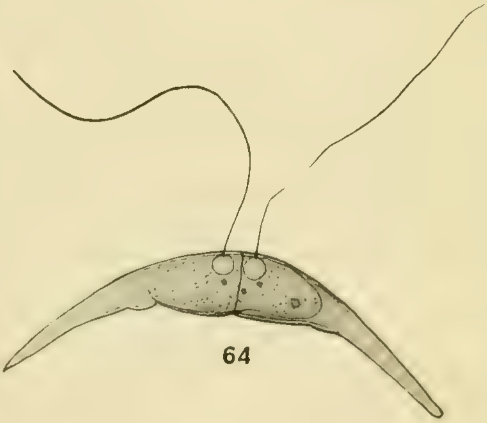
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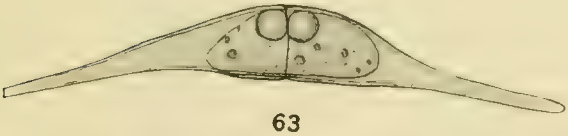
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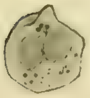
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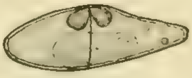
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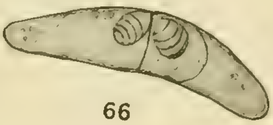
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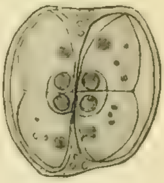
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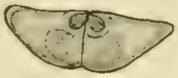
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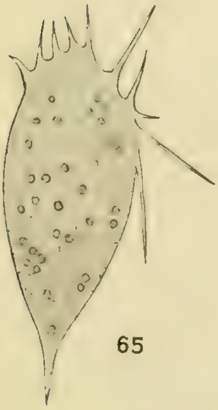
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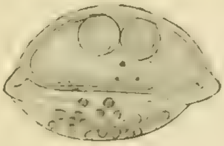
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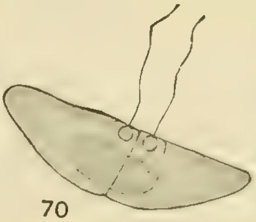
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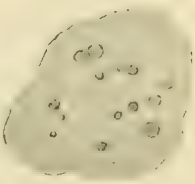
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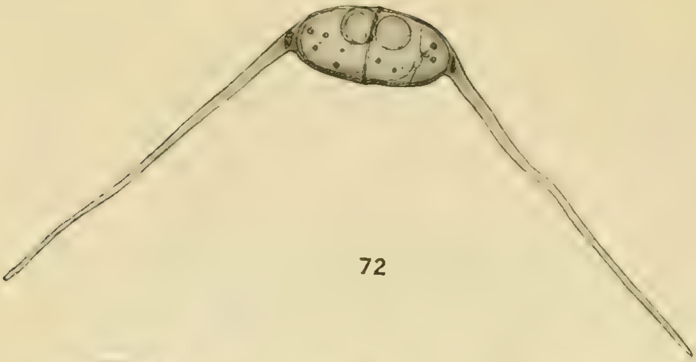
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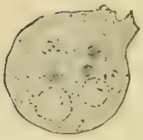
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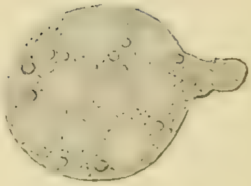
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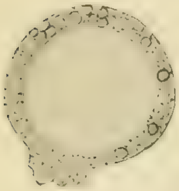
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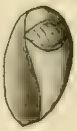
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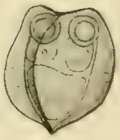
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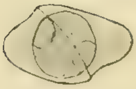
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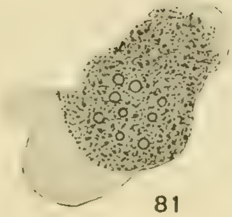
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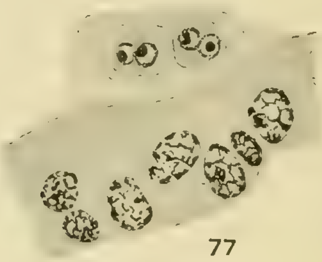
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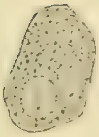
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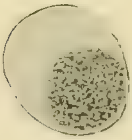
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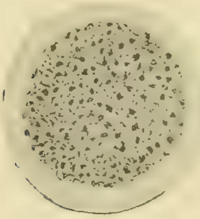
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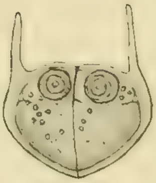
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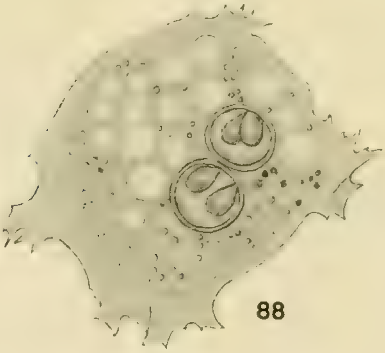
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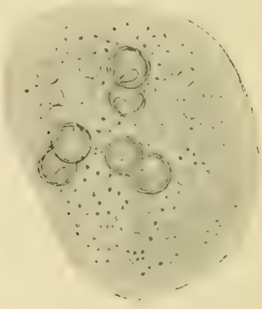
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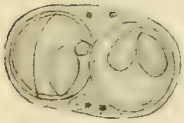
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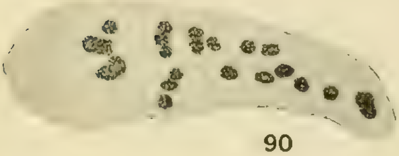
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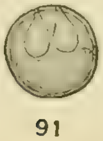
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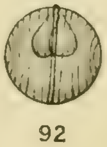
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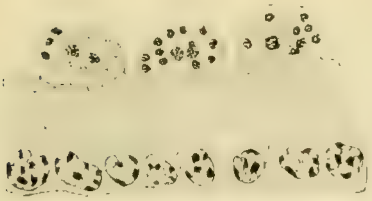

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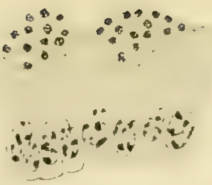

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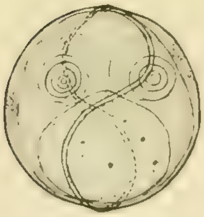

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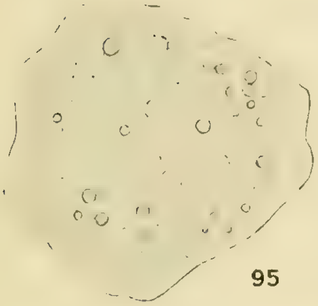

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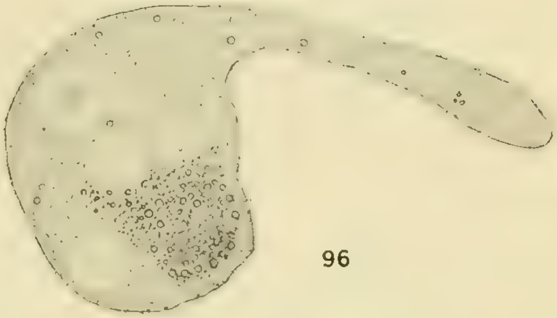

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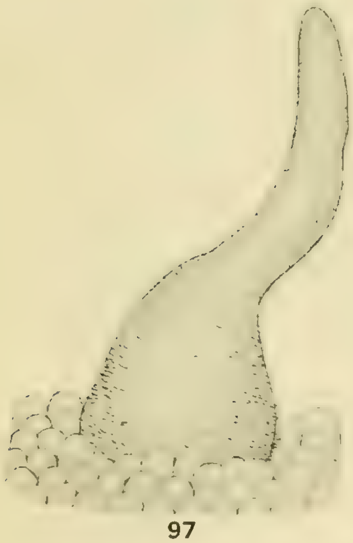

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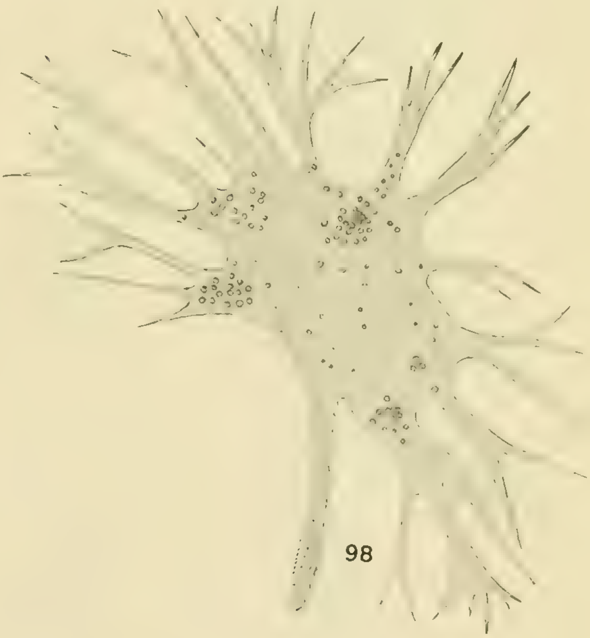

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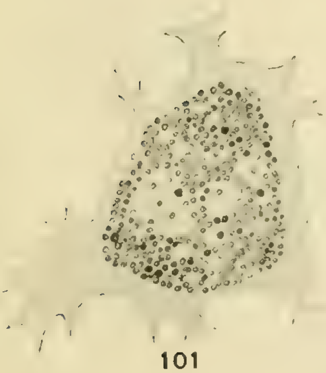

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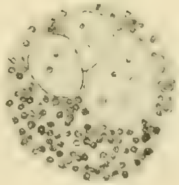

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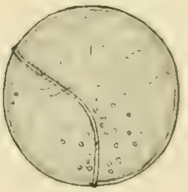

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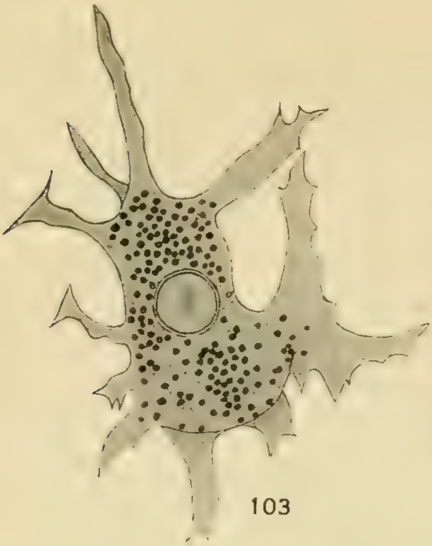

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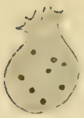

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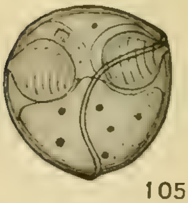

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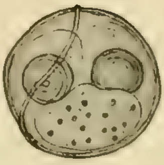

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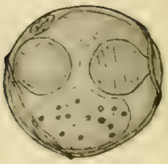

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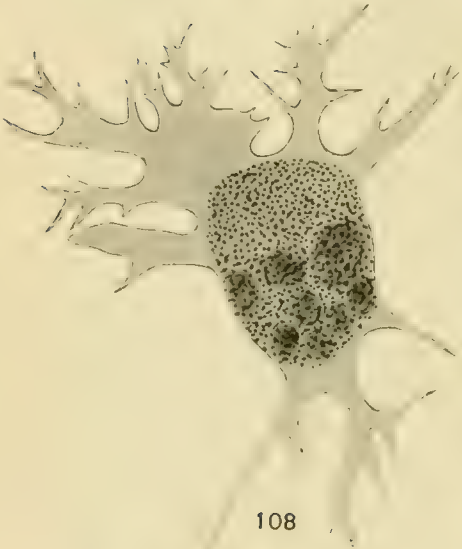

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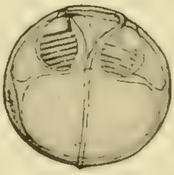

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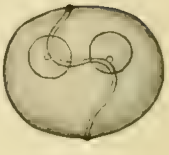

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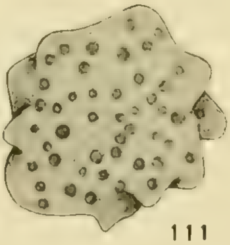

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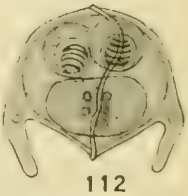

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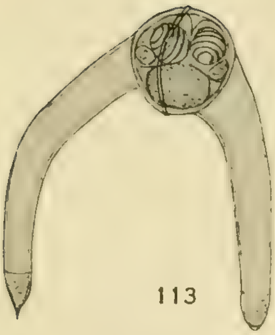

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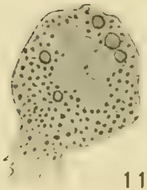

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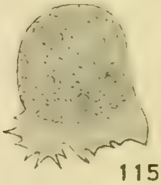

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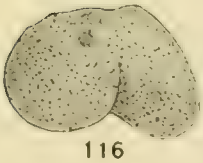

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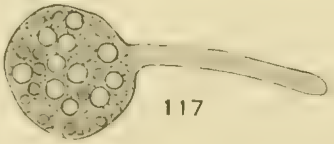

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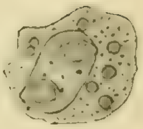

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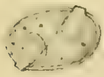
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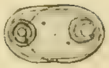
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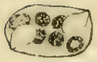
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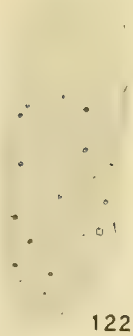
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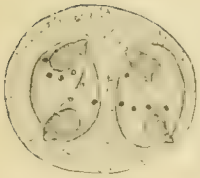
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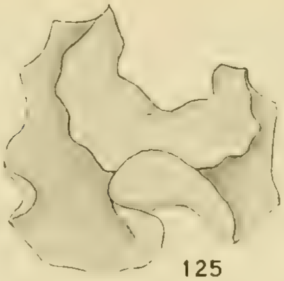
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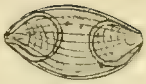
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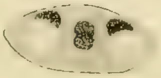
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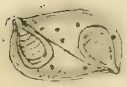
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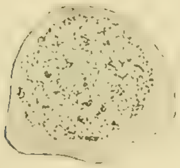
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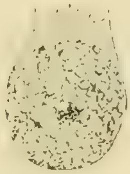
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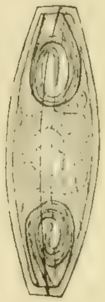
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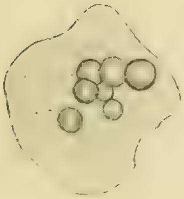
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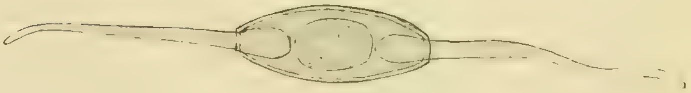
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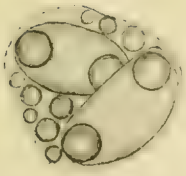
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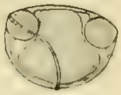
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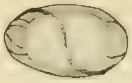
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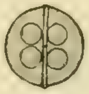
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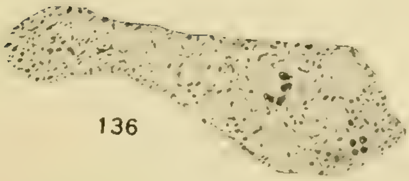
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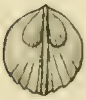
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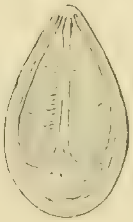
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THE FOOD OF THE SHORE FISHES OF CERTAIN WISCONSIN LAKES

By A. S. Pearse
University of Wisconsin

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THE FOOD OF THE SHORE FISHES OF CERTAIN WISCONSIN LAKES.

By A. S. PEARSE,
University of Wisconsin.

I. INTRODUCTION.

Since the excellent work of Forbes (1880, 1883, 1888) in the eighties no thorough study has been made of the food of fresh-water fishes in the United States. The data for the present paper were collected during 1914, 1915, and 1916 near Madison, Wis. They relate primarily to the shore fishes of lakes, though the food habits of many from other habitats were studied. Small fishes were more often examined than large, because their food habits are less well known. During the first year 383 fishes were examined; during the second, 1,111; and in the third, 125. The summaries for 1914 have already been published (Pearse, 1915). Collections were made at 30 different stations, which are shown in the chart. They may be described briefly as follows:

1. Lake shore at Merrill Springs. A small stream enters a little bay; three large springs flow directly into the lake; shore, sandy and pebbly.
2. Lake shore near Pheasant Branch. Muddy, weedy bottom in mouth of creek; pebbles and a little sand on either side.
3. Lake shore at Maypest. Sandy in shallow water; weedy and soft mud farther out.
4. Six-Mile Creek at fork. Bottom very soft mud; current sluggish.
5. Mouth of Six-Mile Creek. Bottom very soft mud; weedy.
6. Bar across mouth of Catfish Bay. Bottom pebbly.
7. Yahara River above Catfish Bay. Bottom soft mud; current sluggish.
8. Lake shore at Farewells Point. Bottom stony.
9. Small bay near State Insane Asylum. Bottom clay, with water plants.
10. Lake shore in bay. Bottom sandy and pebbly in shallow water; firm mud with weeds in deeper water.
11. Lake shore at Maple Bluff. Beach of rocks and pebbles from the cliff above.
12. Pebble beach east of Maple Bluff.
13. Small bay choked with vegetation; bottom very soft mud.
14. Pebbly beach at mouth of Yahara Canal.
15. Lake in front of University of Wisconsin. In shallow water, sand and bowlders; in deeper water, mud and vegetation followed by soft ooze.
16. Southeast end of University Bay behind bar. Bottom soft mud; abundant vegetation, both floating and attached.
17. Beach outside bar on east side of base of Picnic Point. Bottom pebbly and sandy in shallow water; muddy with weeds at greater depths. Behind bar, soft mud and much vegetation.
18. Beach along southeast side of Picnic Point. Bottom pebbly in shallow water, then sandy, and in deeper water muddy with thick vegetation.
19. Beach northwest of Picnic Point. Bottom of pebbles or sand.

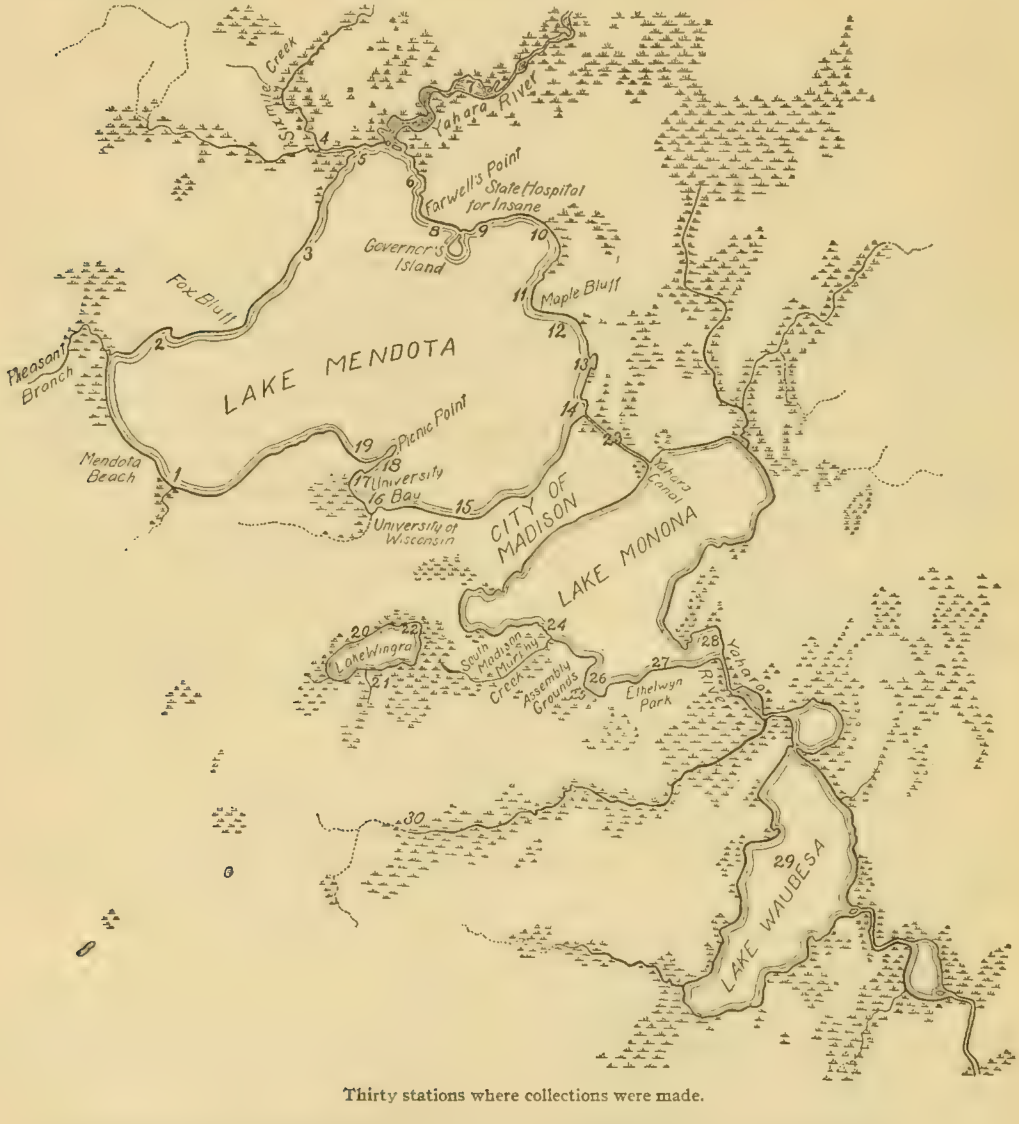
20. Small spring pools on the north shore of Lake Wingra. Bottom soft mud with abundant vegetation.

21. Small creek on south side of Lake Wingra. Bottom clay and mud.

22. Muddy bottom near outlet of Lake Wingra.

23. Yahara Canal, connecting Lake Mendota with Lake Monona. Bottom muddy with thick vegetation; pebbles along shores.

24. Pebble and sand beach on southwest shore of Lake Monona.


Six Mile Creek
Yahara River
4
5
6
Farwell's Point
State Hospital for Insane
7
8
9
10
Governor's Island
3
Fox Bluff
11
Maple Bluff
12
13
2
Pheasant Branch
LAKE MENDOTA
14
Picnic Point
19
18
17
University Bay
16
15
Mendota Beach
1
University of Wisconsin
CITY OF MADISON
23
Yahara Canal
LAKE MONONA
24
20
22
Lake Wingra
21
South Madison
Murphy Creek
Assembly Grounds
25
26
27
Ethelwyn Park
28
Yahara River
30
29
LAKE WAUBESA

Thirty stations where collections were made.

25. Swamp behind Chicago, Milwaukee and St. Paul Railroad near Lake Monona.

26. Turvill Bay. Bottom very soft mud with considerable vegetation.

27. Pebble and sand beach near mouth of Lake Monona.

28. Vegetation filled bay at outlet of Lake Monona. Bottom sand and mud.

29. Catches from power seines of commercial fishermen in Lake Waubesa.

30. Brook near State fish hatchery, 4 miles south of Madison. Bottom clay, stones, and very soft mud.

Collections were made with a miniature fyke net, dip net, minnow seine, and gill net. When they could not be examined within an hour or two, the fishes were placed in 95 per cent alcohol and kept until examined. In examining the food, the entire contents of the alimentary canal were pressed out on a strip of glass, moistened, and then teased apart with needles under a binocular microscope. Insect fragments were turned over to an expert entomologist for identification. As the constituents of the food were identified, they were written in the permanent record. As each fish was completed, the percentage by volume of each constituent was estimated. All figures in this paper refer to such volumetric percentage estimates.

During the work assistance was rendered by a number of persons, and it is a pleasure to acknowledge this indebtedness. Dean E. A. Birge and Mr. Chancey Juday, of the Wisconsin Geological and Natural History Survey, loaned equipment and extended other courtesies. Miss Henrietta Achtenberg worked four months computing averages and rewrote part of the manuscript. Dr. John Lowe and Mr. Alvin Cahn furnished some rare fishes for examination. Mr. A. F. Shira and Mr. Juday read the manuscript and made a number of helpful suggestions. Invaluable assistance was rendered by Dr. R. A. Muttkowski, who identified all the insects.

II. DESCRIPTION OF FOODS.

All figures following foods are given in volumetric percentages; + indicates a trace. The lengths are given in millimeters and exclude the caudal fin. The species are arranged alphabetically according to their scientific names. Under each species the records are arranged according to dates, and the stations (see chart) where collections were made are given in each case.

Abramis crysoleucas (Mitchill). Golden shiner, roach, bream.

Station 5; August 18, 1915; number examined, 2. Length: Maximum, 94; minimum, 92.5; average, 93.2. Food: Hyalella, 42.5; Bosmina, 0.5; Camptocerus, 1.5; filamentous algæ, 40.5; fine silt and débris, 15.

Station 5; August 18; number examined, 5. Length: Maximum, 31.3; minimum, 23.5; average, 28.1. Food: Helea larva, 1; Tanypus carneus larva, 4; insect, 3; water mites, 1.2; ostracods, 4; Cyclops, 33; Canthocamptus, 2; Cladocera unidentified, 14; Bosmina, 14; Pleuroxus, 1.4; Chydorus, 3; Simocephalus, 7; rotifers, 0.8; plant tissue, 4.8; seeds, 0.8; Wolffia, 3; Volvox, 2.2; Closterium, 0.4; Pandorina, 0.4.

Summary.—Food: Dipterous larvæ, 5; insects, 3; water mite, 1.2; ostracods, 4; copepods, 35; Cladocera, 39.4; rotifers, 0.8; plants, 8.6; flagellates, 3.

Station 18; August 18; number examined, 23. Length: Maximum, 75; minimum, 34; average, 39.3. Food: Tanypus monilis pupæ, 12.4; Cyclops, 20; Daphnia longispina hyalina, 65; Simocephalus, 2.1.

Station 5; August 25; number examined, 10. Length: Maximum, 68; minimum, 27.5; average 33.2. Food: Chironomus lobiferus larvæ, 5.5; water mites, 2; Cyclops, 0.2; Bosmina, 88.5; Ceriodaphnia, 3.5; algal filaments, 0.1; Volvox, 0.1.

Station 22; April 1, 1916; number examined, 1. Length: 152. Food: Caddis-fly case, 0.5; ostracods, 90; Cyclops, 0.5; Daphnia pulex, 1; filamentous algæ, 8.

Summary.—Insect larvæ, 0.5; Entomostraca, 91.5; plants, 8.

Station 18; April 13; number examined, 3. Length: Maximum, 137; minimum, 114; average, 122.6. Food: Larvæ sp., 6.6; Chironomus sp. larvæ, 2.3; C. lobiferus larvæ, 0.3; Orthocladius flavus larvæ, 0.3; Copotomus interrogatus adult, 1; Chironomus sp. adult, 38.3; Hyalella, 15; Cyclops, 1; snail remains, 1.6; Valvata tricarinata, 15; Lemna, 15; débris, 3.3.

Summary.—Food: Insect larvæ, 9.5; adult insects, 39.3; amphipods, 15; copepods, 1; Mollusca, 16.6; plants, 15; débris, 3.3.

Station 22; April 22; number examined, 10. Length: Maximum, 133; minimum, 112; average, 123.4. Food: Chironomus decorus larvæ, 3.5; Chironomus sp. larvæ, 2; Cricotopus trifasciatus larvæ, 2.6; May-fly nymphs, 2; chironomid pupæ, 1; Cricotopus trifasciatus pupæ, 1.5; Hyalella, 0.1; ostracod, 0.2; Canthocamptus, 1.5; Cyclops, 33.8; Daphnia pulex, 19.3; Chydorus sphæricus, 5.1; Bosmina, 1.5; Physa, 2; Oscillatoria, 4.7; flagellates, 0.2; Volvox, 0.7; plant remains, 9; algæ, 0.1; fine débris, 9.1.

Summary.—Food: Insect larvæ, 10.1; insect pupæ, 2.5; amphipods, 0.1; Entomostraca, 61.4; Mollusca, 2; Protozoa, 0.2; plants, 14.5; débris, 9.1.

Station 22; June 10; number examined, 5. Length: Maximum, 150; minimum, 115; average, 125. Food: Ostracods, 0.1; Daphnia pulex, 99.9.

Grand summary for 1915 and 1916.—Number examined, 59. Length: Maximum, 152; minimum, 23.5; average, 67.6. Food: Insect larvæ, 4.4; insect pupæ, 5.7; adult insects, 2.2; mites, 0.4; amphipods, 2.2; Entomostraca, 76.1; rotifers, +; protozoans, 1; plant remains, 3.1; algæ, 1.5; débris, 2.2.

From these summaries it is apparent that the chief food of the golden shiner was microscopic crustaceans (76.1 per cent). More than half the food of 10 of the fish consisted of other organisms—81 per cent filamentous algæ, 85 per cent Hyalella, 55 per cent Chironomus lobiferus larvæ, 51 per cent silt and fine débris, etc. All other individuals had eaten 50 per cent or more Entomostraca; some had eaten nothing but Daphnia or Bosmina. Forbes and Richardson (1908) state that the food of this species varies greatly in different situations and mention mud, molluscs, insects, entomostracans, and plants as appearing in the dietary. Hankinson (1908) found midge larvæ and filamentous algæ in the fish he examined. The fish examined by Baker (1916) had eaten a small percentage of molluscs, and about 97 per cent insects, chiefly caddis-fly larvæ. Considering all things, it appears that when young the golden shiner feeds chiefly on entomostracans, and mature fish on almost any available organisms.

Ambloplites rupestris (Rafinesque). Rock bass, red-eye, goggle-eye.

Data for 1914 (Pearse, 1915).—Number examined, 5. Average length: 61.4. Food: Insects, 68; mites, 0.4; Hyalella, 5.6; ostracods, 1; Cladocerans, 15; plants, 4; algæ, 0.2; silt and débris, 0.4.

Station 15; May 27, 1915; number examined, 1. Length: 99. Food: Chironomus fulviventris larvæ, 3; C. decorus larvæ, 10; Procladius sp. larvæ, 10; Molanna uniophila larvæ, 69; Ecdyurus maculipennis nymphs, 2; Chironomus fulviventris pupæ, 5; Valvata tricarinata, 1.

Summary.—Food: Chironomid larvæ, 23; caddis-fly larvæ, 69; May-fly larvæ, 2; chironomid pupæ, 5; snail, 1.

Station 15; June 9; number examined, 1. Length: 115. Food: Siphlurus nymph, 2; Chironomus fulviventris pupa, 3; water mite, 0.5; crayfish, 94.5.

Station 5; June 24; number examined, 1. Length: 188. Food: Enallagma hageni and E. antennatum nymphs, 10; Cambarus propinquus, 90.

Station 15; July 24; number examined, 1. Length: 168. Food: Cambarus propinquus, 100.

Station 18; July 3; number examined, 19. Length: Maximum, 81; minimum, 35.6; average, 53.6. Food: Chironomus lobiferus larvæ, 0.7; C. digitatus larvæ, 1; Cricotopus trifasciatus larvæ, 3.1; Palpomyia longipennis larvæ, 23.1; Leptocerus dilutus larvæ, 2.7; Ichythricha larva, 0.1; damsel-fly nymphs, 4.2; Ecdyurus maculipennis nymphs, 0.7; Enallagma hageni nymphs, 2.7; E. antennatum nymphs, 25; caterpillar, 1; Chironomus lobiferus pupæ, 5.4; Palpomyia longipennis pupæ, 5; same, adult, 11.4; Corixa, 0.7; mites, 0.6; ostracods, 0.3; Eurycercus, 7.6; oligochætes, 2.6; filamentous algæ, 1.

Summary.—Food: Dipterous larvæ, 27.9; caddis-fly larvæ, 2.8; damsel-fly nymphs, 32.6; caterpillar, 1; dipterous pupæ, 10.4; adult insects, 12.1; mites, 0.6; ostracods, 0.3; cladocerans, 7.6; oligochætes, 2.6; algæ, 1.

Station 23; June 14; number examined, 1. Length: 45.5. Food: Chironomus tenellus larvæ, 100.

Station 23; July 23; number examined, 5. Length: Maximum, 99; minimum, 61; average, 76.8. Food: Chironomus fulviventris larvæ, 17.4; Palpomyia longipennis larvæ, 0.4; Cænis diminuta nymphs, 8.5; Enallagma antennatum nymph, 7; parnid beetle larva, 1; Chironomus fulviventris pupæ, 23; Tanypus monilis pupæ, 1.8; Palpomyia longipennis pupæ, 0.4; Probezzia pallida pupa, 5; Simulium vittatum pupa, 1.8; Corixa adults, 2; Berosus, 3.4; Agabus, 2; Haliplus ruficollis, 2.6; crayfish, 12.4; Hyalella, 6; oligochætes, 3; seeds, 0.2; Elodea, 2.

Summary.—Food: Dipterous larvæ, 17.8; caddis fly larvæ, 8.5; damsel fly nymphs, 7; beetle larva, 1; dipterous pupæ, 32; adult insect, 10; crayfish, 12.4; Hyalella, 6; oligochætes, 3; plants, 2.2.

Station 23; August 19; number examined, 1. Length: 66. Food: Carabid-beetle larva, 2; insect remains, 3; plant remains, 75; sand, 20.

Station 18; August 18; number examined, 1. Length: 59. Food: Chironomus viridis larvæ, 20; Bætisca nymphs, 20; Chironomus lobiferus pupæ, 60.

Station 23; August 19; number examined, 1. Length: 22.5. Food: Chironomus lobiferus larvæ, 75; Cyclops, 10; oligochætes, 15.

Station 10; August 20; number examined, 2. Lengths: 31.5, 29. Food: Labidesthes sicculus, 45; Chironomus lobiferus larvæ, 2.5; Chironomus digitatus larvæ, 12.5; Bætisca nymphs, 40.

Station 23; September 21; number examined, 1. Length: 109. Food: oligochætes, 50; plant remains, 20; sand and mud, 30.

Station 15; September 25; number examined, 1. Length: 112. Food: Cambarus propinquus, 100.

Station 15; November 20; number examined, 2. Lengths: 160, 121. Food: Labidesthes sicculus, 42.5; Bætis nymphs, 2.5; Sialis infumata larva, 50; Chironomus lobiferus pupæ, 5.

Station 25; December 4; number examined, 1. Length: 230. Food: Crayfish, 100.

Grand summary for 1914 and 1915.—Number examined, 45. Length: Maximum, 230; minimum, 22.5; average, 72.9. Food: Fish, 2; dipterous larvæ, 19.1; May-fly nymphs, 3.5; Odonata nymphs, 14.4; caddis-fly larvæ, 2.8; Sialis infumata larvæ, 2.2; beetle larvæ, 0.5; unidentified insect larvæ, 0.5; dipterous pupæ, 9.6; Diptera, 4.8; Hemiptera, 1.2; Hymenoptera, 1.3; Coleoptera, 1.1; unidentified insects, 5.3; hydrachnids, 0.2; crayfish, 16.1; amphipods, 1.4; ostracods, 0.3; copepods, 0.3; cladocerans, 4.3; gastropods, +; oligochætes, 3; plant remains, 2.8; algæ, 0.5; silt and débris, 1.2.

The summaries show that the food of the young rock bass consists largely of insects (larvæ, 43 per cent; pupæ, 9.6 per cent; adults, 13.7 per cent), which constitute more than three-fourths of the food. The adult fish feed mostly on crayfish, though they also capture insects in considerable numbers. Forbes and Richardson (1908) state that this bass eats insects, small crustaceans, and a few fish. Hankinson (1908) found that it fed chiefly on crayfish, with smaller percentages of dragon-fly nymphs, midge larvæ, small fishes, and May-fly nymphs. Reighard (1915) found fish, insects, and crayfish in those he examined. According to Baker (1916) about three-quarters of the food is Crustacea and the remainder plants, algæ, insects, and débris.

Ameiurus melas (Rafinesque). Black bullhead.

Data for 1914 (Pearse, 1915).—Number examined, 2. Length: Maximum, 123; minimum, 38.2; average, 80.6. Food: Dipterous larvæ, 40; Diptera, 2.5; ostracods, 12; Cyclops, 2.5; unidentified cladocerans, 1; Bosmina, 25; plant remains, 17.5.

Station 5; August 18, 1915; number examined, 1. Length: 274. Food: Enallagma hageni nymphs, 2; Gyrinus larva, 6; dytiscid larva, 2; Leptocerus larva, 3; Phryganea interrupta larva, 5; caterpillar, 20; Chironomus fulviventris pupa, 16; Chironmus fulviventris adult, 11; Enallagma hageni adult, 13, Psychoda adult, 1; Corixa adult, 10; crayfish claw, 1; Hyalella, 1; leech, 5; Lemna, 3.

Summary.—Food: Insect larvæ, 38; insect pupæ, 16; adult insects, 35; crayfish, 1; Hyalella, 1; leech, 5; Lemna, 3.

Station 5; September 14; number examined, 1. Length: 275. Food: Chironomus decorus larvæ, 30; C. lobiferus larvæ, 20; C. digitatus larvæ, 5; Enallagma hageni nymphs, 5; Chironomus decorus pupa, 30; C. lobiferus pupa, 8; Hyalella, 2.

Summary.—Food: Dipterous larvæ, 60; dipterous pupæ, 38; Hyalella, 2.

Station 28; September 17; number examined, 1. Length: 280. Food: Probezzia glaber larvæ, 4; P. pallida larvæ, 4; Tipula abdominalis larva, 1; Planorbis, 25; Physa, 30; plants, 10; Lemna, 1; Nostoc, 15; silt and débris, 10.

Summary.—Food: Dipterous larvæ, 9; snails, 55; plants, 26; silt and débris, 10.

Station 16; September 20; number examined, 10. Length: Maximum, 190; minimum, 35; average, 79.3. Food: Chironomus decorus larvæ, 6.3; C. fulviventris larvæ, 10; C. tentans larvæ, 0.5; Chironomus sp. larvæ, 11.5; Protenthes culiciformis larva, 0.1; Probezzia glaber larvæ, 1.6; P. pallida larva, 4.5; Chironomus decorus pupæ, 0.6; C. fulviventris adults, 5.4; crayfish, 9.2; Cyclops, 0.5; leech, 4; oligochætes, 32.1; plants, 4.7; silt and fine débris, 8.5.

Summary.—Food: Chironomid larvæ, 24.5; chironomid pupæ, 0.6; chironomid adults, 5.4; crayfish, 9.2; Cyclops, 0.5; leech, 4; oligochætes, 32.1; plants, 4.7; silt and débris, 8.5.

Grand summary for 1914 and 1915.—Number examined, 15. Length: Maximum, 280; minimum, 35; average, 118.8. Food: Dipterous larvæ, 32.6; damsel-fly nymphs, 0.4; beetle larvæ, 0.4; caddis-fly larvæ, 0.5; caterpillar, 1.3; dipterous pupæ, 4.2; adult insects, 5.7; Hyalella, 0.2; crayfish, 6.1; ostracods, 1.6; Cyclops, 0.7; cladocerans, 0.5; snails, 3.7; leech, 3; oligochætes, 21.4; plants, 6.4; algæ, 0.9; silt and débris, 6.3.

The food of the black bullhead, according to the summary, contains 45.1 per cent insects (larvæ, 35.2; pupæ, 4.2; adults, 5.7) and 21.4 per cent oligochætes. Young fish apparently eat more oligochætes than adults. Forbes and Richardson (1908) examined 34 individuals of this species and found the food to be one-fourth plants, and one-fifth bivave molluscs, snails, aquatic insects, crayfishes, and other crustaceans.

Ameiurus nebulosus (Le Sueur). Common bullhead, brown bullhead, speckled bullhead.

Station 5; May 21, 1915; number examined, 16. Length: Maximum, 94; minimum, 54.5; average, 64.7 Food: Unidentified insect larvæ, 1; Chironomus decorus larvæ, 0.2; C. viridicollis larvæ, 1; C. fulviventris larvæ, 0.9; C. tentans larvæ, 8.6; C. lobiferus larvæ, 5.2; Helea larva, 0.3; Cricotopus trifasciatus larvæ, 7.1; Ptychoptera larva, 1; May-fly nymphs, 0.6; Callibætis nymphs, 0.7; beetle larva, 1.2; carabid-beetle larva, 0.3; unidentified pupa, 0.3; Probezzia pupa, 0.6; unidentified insect fragments, 2.2; midges, 0.1; mites, 1.2; Hyalella, 0.6; ostracods, 21; Cyclops, 11; Chydorus sphæricus, 22; Eurycercus lamellatus, 2; Ceriodaphnia, 0.1; cladoceran ephippia, 0.7; snail, 0.5; plants, 2.3; sand and fine débris, 7.3.

Summary.—Food: Insect larvæ, 28.1; insect pupæ, 0.9; adult insects, 2.3; mites, 1.2; ostracods, 21; Cyclops, 11; cladocerans, 24.8; snail, 0.5; plants, 2.3; silt and débris, 7.3.

Station 6; June 24; number examined, 1. Length: 86. Food: Palpomyia longipennis larvæ, 10; Callibætis nymphs, 5; Cænis diminuta nymphs, 10; Enallagma hageni nymphs, 25; fragments of adult insects, 50.

Station 5; August 9; number examined, 33. Length: Maximum, 47.6; minimum, 25; average, 36.2. Food: Unidentified chironomid larvæ and cases, 2.8; Chironomus fulviventris larvæ, 5; C. lobiferus larvæ, 6.3; Protenthes culiciformis larvæ, 7.3; Probezzia glaber larvæ, 1.3; P. pallida larvæ, 0.6; Bætis nymphs, 2; Enallagma hageni nymphs, 1.3; insect pupæ, 0.8; chironomid pupæ, 1; Chironomus lobiferus pupæ, 6; adult midges, 2.3; Anax junius, 0.2; gyrinid beetle, 0.5; Collembola, 0.5; mites, 0.1; Hyalella, 18; ostracods, 2; Cyclops, 6; Bosmina, 0.1; Chydorus sphæricus, 9; Eurycercus, 0.3; Camptocercus, 17; Pleuroxus procurvatus, 4; Acroperus, 0.5; Ceriodaphnia, 1.6; Scapholeberis, 0.3; oligochætes, 4.7.

Summary.—Food: Insect larvæ, 26.6; insect pupæ, 7.8; adult insects, 3.4; mites, 0.1; Hyalella, 18; ostracods, 2; Cyclops, 6; cladocerans, 32.3; oligochætes, 4.7.

Grand summary.—Number examined, 50. Length: Maximum, 94; minimum, 25; average, 46.3. Food: Insect larvæ, 28.2; dipterous pupæ, 2.1; adult insects, 4.4; mites, 0.4; amphipods, 11.4; ostracods, 6.7; copepods, 8.4; cladocerans, 33.1; snails, 0.1; oligochætes, 2.1; rotifers, +; protozoans, +; plants, 0.9; algæ, +; silt and débris, 2.3.

Of the food of this bullhead 42.1 per cent consists of microscopic Crustacea, 34.7 per cent of insects. It apparently feeds more on Entomostraca than the black bullhead. Forbes and Richardson (1908) found the food to consist chiefly of small bivalve molluscs, insect larvæ, distillery slops, and a few adult insects and snails. Hankinson (1908) states that this species is an omnivorous feeder, taking crayfish, fish, molluscs, entomostracans, leeches, beetles, May-fly and dragon-fly nymphs. Tracy (1910) found "all kinds of animal life," including the young and eggs of fishes. Reighard (1915) records small fishes and a bumblebee as food. Crustaceans formed the chief food of the young individuals examined by Baker (1916), while the older fish had eaten 10 per cent Mollusca and 90 per cent vegetation and mud.

The brown bullhead feeds mostly on Entomostraca and insect larvæ while it is young, and when mature takes almost anything in the shape of animal food.

Amiatus calva (Linnæus). Bowfin[a], grindle.

Station 17; August 24, 1915; number examined, 1. Length: 545. Food: Crayfishes, 100.

Station 28; September 14; number examined, 6. Length: Maximum, 438; minimum, 383; average, 406. Food: Fish remains, 37.5; Lepomis incisor, 59.3; crayfish, 3.

Station 28; September 17; number examined, 4. Length: Maximum, 543; minimum, 388; average, 470. Food: Fish remains, 48.5; sunfish, 43.5; crayfish, 7.5.

Station 22; July 1, 1916; number examined, 3. Length: Maximum, 465; minimum, 440; average, 452.6. Food: Fish remains, 96.6; crayfish remains, 3.3.

Summary.—Food: Fish remains, 96.6; crayfish remains, 3.3.

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[a] Locally known as dogfish.

Station 22; July 8; number examined, 1. Length: 420. Food: Fish remains, 100.

Station 22; July 15; number examined, 1. Length, 412. Food: Fish remains, 100.

Summary for 1915 and 1916.—Number examined, 16. Length: Maximum, 465; minimum, 383; average, 467.4. Food: Fish remains, 90.1; crayfish remains, 9.4.

It will be observed that no young dogfish were examined. Forbes and Richardson (1908) examined 20 fish and found the food to be entirely animal—one-third fishes, one-fourth small molluscs, and about 40 per cent crayfishes. A few amphipods, isopods, and entomostracans were also noted (Forbes, 1883).

Boleosoma nigrum (Rafinesque). Johnny darter.

Station 14; July 9, 1915; number examined, 1. Length, 15. Food: Cricotopus trifasciatus larvæ, 10; oligochætes, 55; Cyclops, 20; Chydorus, 15.

Station 5; August 18; number examined, 1. Length, 30. Food: Helea larvæ, 15; Tanypus carneus larvæ, 25; May-fly nymphs, 10; oligochætes, 15; ostracods, 15; Chydorus, 20.

Station 19; August 18; number examined, 10. Length: Maximum, 34.5; minimum, 23; average, 28.7. Food: Tanypus monilis larvæ, 2.4; Chironomus digitatus larvæ, 53.3; C. viridis larvæ, 2.4; C. lobiferus larvæ, 2.5; C. tentans larvæ, 1.5; Ecdyurus maculipennis nymphs, 6.5; C. digitatus pupæ, 1.5; oligochætes, 15; Hyalella, 2.8; Cyclops, 4.7; Chydorus, 1.3; Pleuroxus,+; Ceriodaphnia, 1.6; sand, 4.7.

Summary.—Food: Chironomid larvæ, 63.1; May-fly nymphs, 6.5; chironomid pupæ, 1.5; oligochætes, 15; amphipods, 2.8; copepods, 4.7; cladocerans, 2.9; sand, 4.7.

Station 19; August 20; number examined, 20. Length: Maximum, 32; minimum, 21.5; average, 27.5. Food: Probezzia pallida larvæ, 0.7; Tanypus monilis larvæ, 1.2; Chironomus digitatus larvæ, 46; C. viridis larvæ, 3.5; C. lobiferus larvæ, 8.1; Leptocerus dilutus larvæ, 0.2; C. digitatus pupæ, 2; adult midge, 0.2; oligochætes, 22.4; mite, +; Hyalella, 0.2; ostracods, 0.2; Cyclops, 8.1; Chydorus, 0.1; Pleuroxus, +; Ceriodaphnia, 1.5; Eurycercus, 0.7; Daphnia, 1; sand, 1.9.

Summary.—Food: Chironomid larvæ, 59.5; caddis-fly larvæ, 0.2; chironomid pupæ, 0.2; adult midge, 0.2; oligochætes, 22.4; mites, +; amphipods, 0.2; ostracods, 0.2; copepods, 8.1; cladocerans, 0.4; sand, 1.9.

Station 10; August 20; number examined, 1. Length: 30. Food: Chironomus digitatus larvæ, 20; oligochætes, 42; Hyalella, 10; Cyclops, 15; Chydorus, 3; Ceriodaphnia, 10.

Station 12; August 20; number examined, 1. Length: 32.5. Food: Chironomus digitatus larvæ, 60; Hyalella, 30; Eurycercus, 10.

Station 5; August 25; number examined, 1. Length, 38.2. Food: Chironomus digitatus larvæ, 47; C. lobiferus larvæ, 40; oligochætes, 5; ostracods, 3; Cyclops, 5.

Station 5; August 30; number examined, 1. Length: 41.5. Food: Chironomus lobiferus larvæ, 10; Protenthes culiciformis larvæ, 10; oligochætes, 47; Cyclops, 30; diatoms, 3.

Station 14; August 31; number examined, 3. Lengths: 41, 36.5, 29; average, 35.6. Food: Chironomid larva, 5; Cricotopus trifasciatus larva, 2.3; Chironomus digitatus larvæ, 35; C. viridis larvæ, 2.3; Protenthes culiciformis larvæ, 2.3; mites, 0.3; Hyalella, 15; Cyclops, 8; Chydorus, 18; sand, 10.

Summary.—Food: Chironomid larvæ, 46.9; mites, 0.3; amphipods, 15; copepods, 8; cladocerans, 18; sand, 10.

Station 1; September 1; number examined, 10. Length: Maximum, 48.5; minimum, 27.5; average, 34.9. Food: Cricotopus trifasciatus larvæ, 1.4; Chironomus digitatus larvæ, 41.5; C. viridis larvæ, 1.1; C. lobiferus larvæ, 7.4; C. tentans larvæ, 3.5; Corethra larvæ, 0.2; Cænis diminuta nymphs, 0.5; C. digitatus pupæ, 1.5; oligochætes, 13.7; Hyalella, 13.9; Cyclops, 5; Chydorus, 0.1; Pleuroxus, 0.2; Eurycercus, 6.3; cladoceran, 0.1; sand, 3.5.

Summary.—Food: Chironomid larvæ, 55.1; May-fly nymphs, 0.5; chironomid pupæ, 1.5; oligochætes, 13.7; amphipods, 13.9; copepods, 5; cladocerans, 6.7; sand, 3.5.

Station 5; September 2; number examined, 2. Lengths: 41, 31. Food: Insect eggs, 2.5; Probezzia pallida larvæ, 11; Chironomus digitatus larvæ, 5; C. lobiferus larvæ, 45.5; C. tentans larvæ, 21.5; adult midge, 0.5; oligochætes, 5; Cyclops, 5; cladoceran, 1; sand, 3.

Summary.—Food: Chironomid larvæ, 85.5; midge, 0.5; oligochætes, 5; copepods, 5; cladocerans, 1; sand, 3.

Grand summary.—Number examined, 50. Length: Maximum, 48.5; minimum, 21.5; average, 30.9. Food: Insect larvæ, 59.2; insect pupæ, 1.4; adult insects, 0.1; oligochætes, 18.4; amphipods, 5.1; ostracods, 0.5; copepods, 7.4; cladocerans, 5.6; diatoms, +; sand, 3.1.

The chief food of the Johnny darter is chironomid larvæ, with oligochætes forming the second largest item. Forbes and Richardson (1908) stated that the food of the fish they examined consisted of two-thirds chironomid larvæ, 12 per cent small May flies, and 7 per cent gnat larvæ. Hankinson (1908) reported chiefly midge larvæ, with some filamentous algæ and Entomostraca. Reighard (1915) found midge larvæ and entomostracans.

Catostomus commersonii (Lacépède). Common sucker, fine-scaled sucker.

Station 24; July 2, 1915; number examined, 23. Length: Maximum, 24.3; minimum, 13; average, 19.9. Food: Chironomus lobiferus eggs, 0.1; C. lobiferus larvæ, 5.2; C. digitatus larvæ, 5.6; C. viridis larvæ, 1.3; C. flavus larvæ, 1.3; C. tentans larvæ, 2.4; Cricotopus trifasciatus larvæ, 41.3; C. tentans pupæ, 3.4; bug, +; midge, 0.3; ostracods, 17.5; Cyclops, 3.7; Cladoceran, 2.2; Bosmina, 1.1; Chydorus, 1.5; Eurycercus, +; oligochætes, 13.5; rotifers, 0.1; Closterium, +; Pediastrum, +; diatoms and desmids, +; Aphanothece, 0.1.

Summary.—Food: Chironomid larvæ, 55.9; chironomid pupæ, 3.4; adult insects, 0.3; ostracods, 17.5; copepods, 3.7; cladocerans, 3.9; oligochætes, 13.5; rotifers, 1; Protozoa, +; algæ, 0.1.

Station 5; August 25; number examined, 6. Length: Maximum, 60; minimum, 38.5; average, 47.9. Food: Chironomus lobiferus larvæ, 0.5; Probezzia glaber larvæ, 0.8; ostracods, 12.3; Cyclops, 48.4; cladocerans, 0.3; oligochætes, 7; Arcella, 0.1; Difflugia, 8.5; Closterium, 1.6; desmids and diatoms, 2.5; fine silt and débris, 16.9.

Summary.—Food: Chironomid larvæ, 1.3; ostracods, 12.3; copepods, 48.4; cladocerans, 0.3; oligochætes, 7; protozoans, 8.6; algæ, 4.1; silt and débris, 16.9.

Station 5; August 30; number examined, 3. Length: 58, 53.6, 44; average, 51.8. Food: Chironomus lobiferus larvæ, 4; Corethra adult, 2.3; Dytiscus, 2.3; mite, +; ostracods, 27; Cyclops, 14; chydorid, 6.3; oligochætes, 10; rotifers, 1.3; Arcella, 0.3; Difflugia, 1; Closterium, 10.3; desmids and diatoms, 14; silt and débris, 4.3.

Summary.—Food: Chironomid larvæ, 4; adult insects, 4.6; ostracods, 27; copepods, 14; cladocerans, 6.3; oligochætes, 10; rotifers, 1.3; protozoans, 1.3; algæ, 24.3; silt and débris, 4.3.

Station 5; September 2; number examined, 1. Length: 44. Food: Enallagma eggs, 25; Cyclops, 56; Chydorus, 1; oligochætes, 10; rotifers, 1: Difflugia, 1; desmids and diatoms, 1; silt and débris, 5.

Grand summary.—Number examined, 34. Length: Maximum, 60; minimum, 13; average, 29.2. Food: Insect eggs, 0.7; chironomid larvæ, 40.6; chironomid pupæ, 2.4; adult insects, 0.6; mites, 0.1; ostracods, 16.8; copepods, 14.8; cladocerans, 3.6; oligochætes, 11.5; rotifers, 0.2; Protozoa, 1.3; algæ, 3; silt and débris, 3.6.

The common sucker when young feeds mostly on chironomid larvæ (40.6 per cent), entomostracans (35.2 per cent), and oligochætes (11.5 per cent). Tracy (1910) described the young as feeding on diatoms, desmids, and black-fly larvæ; the adults on insects, worms, molluscs, young fishes, and fish eggs. Reighard (1915) found that the young ate mostly cladocerans, 2,000 being found in one individual. He told how the adults mouth over plants from one end to the other, and stated that they ate the eggs of the log perch. Hankinson (1908) found the food of adults to consist of caddis-fly larvæ and cases, Sphæridæ, amphipods, insects, marl, midge larvæ, and Daphnia. Baker (1916) reported his examinations as follows: Mud and plant remains, 49 per cent; molluscs, 30 per cent; insecta, 21 per cent.

The sucker is remarkable for the fineness of the food it is able to select. No other fish shows such a high percentage of protozoans, unicellular algæ, and rotifers in its food.

Cottus ictalops (Rafinesque). Miller's thumb, common sculpin.

Data for 1914 (Pearse, 1915).—All from station 11; number examined, 10. Average length, 45. Food: May-fly nymphs, 66; chironomid larvæ, 7.1; adult midge, 1.5; Hyalella, 13.5; ostracods, 0.5; Cyclops, 1.5; leech, 9; filamentous algæ, 0.9.

Station 14; July 9, 1915; number examined, 2. Lengths: 21.7, 20.5. Food: Cricotopus adults, 7.5; Hyalella, 60; ostracods, 2.5; Cyclops, 10; chydorid, 2.5; oligochætes, 10; filamentous algæ, 7.5.

Station 23; July 23; number examined, 1. Length: 57.5. Food: Chironomus fulviventris larvæ, 10; Diamesi waltii larvæ, 10; Hyalella, 60; oligochætes, 15; plant remains, 5.

Station 19; August 18; number examined, 1. Length: 31. Food: Chironomus lobiferus larvæ, 40; Hyalella, 60.

Station 19; August 20; number examined, 2. Lengths: 33, 32.5. Food: Chironomus digitatus larvæ, 21.5; Hyalella, 75; sand, 3.5.

Station 19; August 30; number examined, 2. Lengths: 33.5, 41. Food: Hyalella, 96; oligochætes, 4.

Station 19; August 31; number examined, 2. Lengths: 30.5, 30.5. Food: Chironomus digitatus larvæ, 10; C. viridis larvæ, 10; Cænis diminuta nymphs, 8.5; Hyalella, 68.5; Cyclops, 1; oligochætes, 0.5; sand, 1.5.

Station 14; August 31; number examined, 1. Length: 35.5. Food: Chironomus digitatus larvæ, 10; Bætisca nymphs, 30; Hyalella, 60.

Station 1; September 1; number examined, 1. Length: 35. Food: Chironomus digitatus larvæ, 5; Bætisca nymphs, 15; Hyalella, 80.

Station 11; September 2; number examined, 5. Length: Maximum, 46; minimum, 31.5; average, 40. Food: Chironomus digitatus larvæ, 0.4; Heptagenia interpunctata larvæ, 0.6; Hyalella, 98; ostracods, 1.

Station 11; September 11; number examined, 2. Lengths: 49, 39. Food: Hyalella, 95; ostracods, 1; Nostoc, 4.

Station 1; October 2; number examined, 1. Length: 48. Food: Dikerogammarus fasciatus, 100.

Grand summary for 1914 and 1915.—Number examined, 30. Length: Maximum, 57.5; minimum, 20.5; average, 39.6. Food: Chironomid larvæ, 7.5; caddis-fly larvæ, 0.1; May-fly nymphs, 24; adult midges, 1; amphipods, 59.1; ostracods, 0.6; copepods, 1.2; cladocerans, 0.1; oligochætes, 0.7; leeches, 3; plant remains, 0.1; algæ, 1; sand, 0.2.

The miller's thumb subsists mostly on amphipods and insect larvæ. It evidently lurks under stones and rushes out to capture small things which swim by. Forbes and Richardson (1908) examined six individuals, and 25 per cent of the food consisted of small fishes, 40 per cent of insect larvæ, and the remainder mostly Asellus. They also stated that this fish was said to be very destructive to the eggs and fry of trout.

Cyprinus carpio Linnæus. German carp.

Station 23, in a little inland pool connected with Yahara Canal by a ditch; July 12, 1915; number examined, 4. Length: Maximum, 21.7; minimum, 18; average, 20.1. Food: Unidentified chironomid larvæ, 5.2; Probezzia pallida larvæ, 2.5; Tanytarsus agrayoloides larvæ, 10; Gyrinus larvæ, 2.5; Dytiscus hybridus larvæ, 2.5; Diamesi waltii larvæ, 4.2; D. waltii pupæ, 2.7; Palpomyia longipennis pupæ, 0.7; Leptocella uwarowii adult, 17.5; Collembola, 2.5; ostracods, 28.7; Cyclops, 2.5; Chydorus 1.2; rotifers, 13.7; colonial algæ, 0.7; desmids, 0.2; Wolffia, 2.5.

Summary.—Food: Chironomid larvæ, 21.9; beetle larvæ, 5; chironomid pupæ, 3.2; adult insects, 20; ostracods, 28.7; copepods, 2.5; cladocerans, 1.2; rotifers, 3.7; plants, 2.5; algæ, 0.9.

Station 5; August 9; number examined, 18. Length: Maximum, 64; minimum, 15; average, 31.8. Food: Helea larvæ, 0.8; Chironomus fulviventris larvæ, 7; C. lobiferus larvæ, 2; Cricotopus trifasciatus larvæ, 0.3; Probezzia pallida larvæ, 0.8; May-fly nymphs, 0.8; Cænis diminuta nymphs, 3; Berosus larvæ, 0.3; Haliplus larvae, 0.1; Corixa nymph, 2.7; Palpomyia longipennis adults, 0.3; C. fulviventris adults, 2.5; Corethra adults, 2.5; Dytiscus adults, 2.5; Hyalella, 16.3; ostracods, 9.4; Cyclops, 14; Canthocamptus, 0.5; mites, 1.7; Ceriodaphnia, 1.4; Chydorus, 3.7; Camptocercus, 0.8; Pleuroxus, 0.7; unidentified cladocerans, 0.8; ephippial eggs, 0.5; unidentified snalis, 6.4; Physa, 1.6; Planorbis, 2; oligochætes, 6.3; Pleurococcus, 1.4; Wolffia, 4.7; plant remains, 1.6.

Summary.—Food: Insect larvæ, 17.7; adult insects, 7.8; mites, 1.7; Hyalella, 16.3; ostracods, 9.4; copepods, 14.5; cladocerans, 7.9; snails, 9; oligochætes, 6.3; algæ, 1.4; plants, 6.3

Station 23, in a little inland pool connected with Yahara Canal by a ditch; August 11; number examined, 18. Length: Maximum, 44.6; minimum, 21; average, 29.5. Food: Insect eggs, 0.6; Chironomus fulviventris larvæ, 53.1; C. lobiferus larvæ, 5; C. tentans larvæ, 2.5; Palpomyia longipennis larvæ, 0.5; May-fly nymphs, 1; Cænis diminuta nymphs, 4. 9; Naucoris larvæ, 0.1; Chironomus fulviventris pupæ, 7.2; adult insects, 1; Haliplus maculatus adults, 1.5; Chironomus fulviventris adults, 0.3; Corethra adults, 1.5; mites, 2.8; ostracods, 0.3; Cyclops, 8.9; Ceriodaphnia, 0.3; Chydorus, 0.5; Cladoceran, 0.1; snails, 0.8; Physa, 0.8; Planorbis, 4.3; rotifers, +; Difflugia, +; filamentous algæ, 0.3; plant remains, 0.2; silt, 0.3.

Summary.—Food: Insect larvæ, 67.6; insect pupæ, 7.2; adults, 4.3; mites, 2.8; ostracods, 0.3; copepods, 8.9; cladocerans, 0.9; snails, 5.9; rotifers, +; protozoans, +; algæ, 0.3; plants, 0.2; silt, 0.3.

Station 28; September 14; number examined, 1. Length: 460. Food: Chironomid larvæ, 1; ostracods, 1; Cyclops, 2; plant remains, 61; duckweed, 7; blue grass, 8; fine silt and débris, 20.

Station 22; April 22, 1916; number examined, 1. Length: 120. Food: Chironomid sp. larvæ, 30; ostracods, 4.8; Cyclops, 24; chydorid, 0.1; Chydorus, 0.1; plant remains, 1; bottom débris, 40.

Summary.—Food: Insect larvæ, 30; Entomostraca, 29; plants, 1; débris, 40.

Grand summary for 1915 and 1916.—Number examined, 42. Length: Maximum, 460; minimum, 15; average 41.7. Food: Insect larvæ, 39.7; insect pupæ, 6.8; adult insects, 3.5; mites, 1.8; amphipods, 6.9; entomostracans, 20.9; snails, 6.9; oligochætes, 2.8; rotifers, 1.1; protozoans, +; algæ, 0.8; plant remains, 4.9; silt and débris, 1.5.

The German carp during its first few weeks after hatching from the egg feeds largely on entomostracans and rotifers; after that it turns more to insect larvæ. The adult carp is rather omnivorous, but vegetation forms a large part of its food. Forbes and Richardson (1908) stated that the carp eats principally vegetable matter, also insect larvæ, crustaceans, molluscs, and other small aquatic animals. Tracy (1910) said it is omnivorous and chiefly vegetarian in its diet. Cole (1905) stated that the food was mostly vegetable and mentioned many other things he found, including the eggs of whitefish.

Esox lucius Linnæus. Common pike, pickerel.

Station 17; April 17, 1915; number examined, 1. Length: 730. Food: Micropterus salmoides (165 mm. long), 55; Perca flavescens (160 mm.), 45.

Station 17; April 25; number examined, 1. Length: 765. Food: Perca flavescens (185 mm.), 100.

Station 15; June 12; number examined, 1. Length: 164.5. Food: Perca flavescens (95 mm.), 100.

Station 23; July 23; number examined, 1. Length: 143. Food: Diamesi waltii adult, 5; Hyalella, 95.

Station 15; June 26; number examined, 1. Length: 420. Food: Fish remains, 100.

Station 15; August 7; number examined, 1. Length: 155.5. Food: Fish remains, 90; Sphæridæ, 10.

Station 15; August 21; number examined, 1. Length: 587. Food: Perca flavescens (134 mm.), 100.

Station 17; August 23; number examined, 2. Lengths: 362, 400. Food: Perca flavescens (140 mm., 105 mm.), 100.

Station 17; August 24; number examined, 1. Length: 317. Food: Fish remains, 90; Corixa nymphs, 4; Naucoris larvæ, 4; ephippial eggs, 2.

Station 28; September 17; number examined, 4. Length: Maximum, 555; minimum, 455; average, 487. Food: Small sunfish, 50; fish remains, 50.

Station 29; November 16; number examined, 2. Lengths: 876, 563. Food: Perca flavescens (200 mm.), 50; fish remains, 50.

Station 22; April 1, 1916; number examined, 1. Length: 233. Food: Fish remains, 100.

Station 18; April 13; number examined, 4. Length: Maximum, 238; minimum, 200; average, 217.5. Food: Fish remains, 100.

Station 18; April 17; number examined, 1. Length, 227. Food: Notropis heterodon and other fish remains, 100.

Station 18; April 18; number examined, 2. Lengths: 293, 203; average, 248. Food: Chydorus, 50; leech, 50.

Station 27; May 30; number examined, 2. Lengths: 320, 295; average, 305. Food: Pimephales notatus, 50; Perca flavescens, 50.

Station 18; June 29; number examined, 1. Length: 220. Food: Fish remains, 100.

Station 18; June 12; number examined, 1. Length: 45. Food: Minnow, 50; chironomid larvæ, 20; Cænis diminuta nymphs, 30.

Station 18; July 7; number examined, 2. Length: Maximum, 100; minimum, 90; average, 95. Food: Fish remains, 50; Perca flavescens, 50.

Station 17; July 10; number examined, 6. Length: Maximum, 100; minimum, 81; average, 88.8. Food: Micropterous salmoides, 66.6; Perca flavescens, 16.6; Cænis diminuta nymphs, 10; midge pupæ, 6.6.

Grand summary for 1915 and 1916.—Number examined, 36. Length: Maximum, 876; minimum, 45; average, 293.4. Food: Fish, 84; insect larvæ, 2.9; insect pupæ, 1; adult insects, 2.5; amphipods, 2.5; Entomostraca, 2.6; Hirudinea, 2.5; Mollusca, 0.2; silt and débris, 1.2.

The small pickerel apparently eats a few insects and molluscs; the adults live nearly altogether on fish. Other observers have found the food to be as follows: Forbes and Richardson (1908)—fishes and frogs, crayfishes, larger insects, and occasionally even mice, reptiles, and young ducks; Hankinson (1908)—perch, darters; Reighard (1915)—perch and fish remains.

Etheostoma flabellare Rafinesque, var. lineolatum Jordan and Evermann. Fan-tailed darter.

Data for 1914.—Station 11; September 4; number examined, 2. Lengths: 29.6, 31.3. Food: Chironomid larvæ, 75; adult midge, 0.5; Hyalella, 24.5; Camptocercus, +.

Station 19; December 3; number examined, 1. Length: 38.7. Food: Chironomus lobiferus larvæ, 35; C. viridis larvæ, 40; Hyalella, 25.

Station 23; July 12, 1915; number examined, 1. Length: 48.3. Food: Hyalella, 80; oligochætes, 15; plant remains, 5.

Station 14; August 31; number examined, 1. Length: 38.7. Food: Agraylea multipunctata larvæ, 13; Hyalella, 86; chydorid, 1.

Grand summary for 1914 and 1915.—Number examined, 5. Length: Maximum, 48.3; minimum, 29.6; average, 37.3. Food: Chironomid larvæ, 42; caddis-fly larvæ, 4.8; adult midge, 0.2; Hyalella, 48; cladocerans, 0.2; oligochætes, 3; plant remains, 1.

The fan-tailed darter lives mostly on chironomid larvæ and amphipods. Forbes and Richardson (1908) examined six fish and found two-thirds chironomid larvæ, one-fourth May-fly nymphs, and the remainder copepods.

Etheostoma iowæ Jordan and Meek. Iowa darter.

Station 23; July 9, 1915; number examined, 4. Length: Maximum, 55; minimum, 45.5; average, 48.5. Food: Unidentified chironomid larvæ, 12.5; Chironomus fulviventris larvæ, 11.2; C. tentans larvæ, 2.5; Berosus larvæ, 9; Gyrinus larvæ, 11.2; Hyalella, 47.5; Physa heterostropha, 3.7; oligochætes, 2; fine débris, 0.5.

Station 23; August 31; number examined, 1. Length: 45. Food: Hyalella, 100.

Grand summary.—Number examined, 5. Average length, 47.8. Food: Chironomid larvæ, 21; beetle larvæ, 16; amphipods, 58; snails, 3; oligochætes, 1.6; fine débris, 0.4.

This beautiful little darter subsists nearly altogether on amphipods and insect larvæ.

Eucalia inconstans (Kirtland). Brook stickleback.

Data for 1914 (Pearse, 1915).—Number examined, 50. Length: Maximum, 48.5; minimum, 22; average, 31.7. Food: Dipterous larvæ, 13.2; May-fly nymphs, 1.4; Corixa nymphs, +; caddis-fly larvæ, 1.3; unidentified adult insects, 2.2; midges, 13.6; podurans, 0.7; mites, 0.5; Hyalella, 0.2; ostracods, 3.6; copepods, 28.5; cladocerans, 14.9; snails, 6.3; Sphæridæ, 0.1; oligochætes, 0.3; nematodes, +; rotifers, +; Difflugia, +; plants, 5.4; algæ, 1.7; fine débris, 4.6.

Station 21; April 28, 1915; number examined, 10. Length: Maximum, 51; minimum, 30.1; average, 40.6. Food: Chironomid larvæ, 2.5; Pelopia flavifrons larvæ, 1.5; Chironomus fulviventris larvæ, 2; C. flavus larvæ, 3; C. lobiferus larvæ, 0.6; C. modestus larvæ, 0.2; C. digitatus larvæ, 0.2; Tanytarsus dissimilis larvæ, 0.2; Orthocladius sp. larvæ, 0.7; Cricotopus exilis larvæ, 0.4; Cricotopus trifasciatus pupæ, 0.2; Chironomid adults, 3.8; Hyalella, 11.5; Dikerogammarus fasciatus, 15.2; young amphipods, 5.5; ostracods, 5; Cyclops, 12; Canthocamptus, 1; oligochætes, 7.3; rotifers, 4.3; diatoms, +; algæ, 0.5; filamentous algæ, 0.2; gelatinous algæ, 0.5; plant remains, 8.5; silt and fine débris, 16.6.

Summary.—Food: Chironomid larvæ, 11.3; chironomid pupæ, 0.2; adult midges, 3.8; amphipods, 32.2; ostracods, 5; copepods, 13; oligochætes, 7.3; rotifers, 4.3; algæ, 1.2; plants, 8.5; silt and débris, 16.6.

Station 20; April 28; number examined, 10. Length: Maximum, 44; minimum, 31; average, 40.6. Food: Fish eggs and embryos, 2.5; Pelopia flavifrons larvæ, 0.3; chironomid larvæ, 0.9; C. flavus larvæ, 0.7; C. lobiferus larvæ, 0.7; C. dorsalis larvæ, 0.2; C. tentans larvæ, 0.6; C. viridicollis larvæ, 0.2; Tanytarsus exiguus larvæ, 3.4; Orthocladius nivoriundus larvæ, 0.9; adult midge, 0.5; insect, 1.5; Asellus communis, 14; Dikerogammarus fasciatus, 3; ostracods, 3.7; Cyclops, 16.8; Canthocamptus, 7.3; Chydorus sphæricus, 32.2; Physa, 7.5; Physa eggs, 1; oligochætes, 1; filamentous algæ, 0.1; silt and débris, 0.6.

Summary.—Food: Chironomid larvæ, 10.4; adult insects, 2; amphipods, 17; ostracods, 3.7; copepods, 21.1; cladocerans, 32.2; snails, 8.5; oligochætes, 1; algæ, 0.1 silt and débris, 0.6.

Station 20; June 12; number examined, 30. Length: Maximum, 43.5; minimum, 9.4; average, 19.1. Food: Caddis-fly larvæ, 1.1; chironomid larvæ, 7.1; Chironomus tentans, 8.9; psychodid larvæ, 0.3; Tanytarsus exiguus larvæ, 6.4; Orthocladius sp. larvæ, 0.5; O. nivoriundus larvæ, 0.8; Cricotopus, exilis larvæ, 1.9; C. trifasciatus larvæ, 5; C. trifasciatus pupæ, 11.4; Chironomus tentans pupæ, 17.3; C. fulviventris pupæ, +; Aedes adults, 1; leaf hopper, 1; ostracods, 2.5; Cyclops, 4.8; Canthocamptus, 1.5; nauplii, 0.1; Chydorus sphæricus, 20; Ceriodaphnia, 0.9; rotifers, 4.3; diatoms, 0.1; filamentous algæ, 0.1; plant remains, 0.1.

Summary.—Food: Chironomid larvæ, 30.9; caddis-fly larvæ, 1; chironomid pupæ, 28; adult insects, 2; ostracods, 2.5; copepods, 6.4; cladocerans, 20.9; rotifers, 4.3; algæ, 1.1; plants, 0.1.

Station 21; June 12; number examined, 6. Length: Maximum, 42; minimum, 30; average, 37. Food: Chironomid larvæ, 0.2; Chironomus fulviventris larvæ, 64.6; Tanytarsus exiguus larvæ, 4.3; Chironomus fulviventris pupæ, 20; Aedes adults, 5.8; Hyalella, 3.6; Cyclops, 1.3; amphipods, 3.6; copepods, 1.3.

Summary.—Food: Chironomid larvæ, 69.1; chironomid pupæ, 20; adult mosquitoes, 5.8; amphipods, 3.6; copepods, 1.3.

Station 25, from a ditch beside the road; July 2; number examined, 4. Length: Maximum, 28.6; minimum, 13.2; average, 19.6. Food: Chironomid larvæ, 2.5; Tanytarsus exignus larvæ, 6.2; Tanytarsus monilis larvæ, 28.2; adult midge, 1.2; Hermannia bistriata, 11.2; ostracods, 13.7; Cyclops, 22.5; Ceriodaphnia, 1.2; oligochætes, 7.2; rotifers, 4.7; diatoms, 1; gelatinous algæ, 1.2.

Summary.—Food: Chironomid larvæ, 36.9; midge, 1.2; terrestrial mite, 11.2; ostracods, 13.7; copepods, 22.5; cladocerans, 1.2; oligochætes, 7.2; rotifers, 4.7; algæ, 2.2.

Grand summary for 1914 and 1915.—Number examined, 110. Length: Maximum, 51; minimum 9.4; average, 29.3. Food: Fish eggs, 0.2; dipterous larvæ, 21.5; hemipterous larvæ, +; May-fly larvæ, 0.6; caddis-fly larvæ, 0.9; chironomid pupæ, 9.1; adult Diptera, 7.3; hemipterous adults, 0.3; podurans, 0.3; unidentified insects, 1.1; mites, 0.6; amphipods, 3.4; Asellus, 1.2; ostracods, 3.2; copepods, 19.3; cladocerans, 16; snails, 3.6; Sphæridæ, 0.1; oligochætes, 1.1; rotifers, 1.1; nematodes, +; algæ, 1.2; plants, 3.2; silt and débris, 3.7.

The brook stickleback ate over 41 per cent insects (larvæ, 23; pupæ, 9.1; adults, 9) and 38.5 per cent entomostracans. Forbes and Richardson (1908) examined five fish and found about equal parts of plant and animal food—filamentous algæ, insects, chironomid larvæ, and entomostracans.

Eupomotis gibbosus Linnæus. Pumpkinseed.

Station 17; April 10, 1915; number examined, 3. Lengths: 155, 148, 145. Food: Protenthes, choreus larvæ, 0.6; Chironomus fulviventris larvæ, 0.6; Enallagma hageni nymphs, 2.6; Sialis larvæ, 1.6; Colymbetis adults, 20; leeches, 8.3; Planorbis, 40; plant remains, 22.6; fine débris, 3.3.

Station 17; April 13; number examined, 2. Lengths: 133, 126. Food: Toad eggs, 42.5; Planorbis, 30; plant remains, 5; algæ, 15; fine débris, 7.5.

Station 28; August 19; number examined, 1. Length: 116. Food: Chironomus lobiferus larvæ, 15; Chrysops larvæ, 1; Chironomus lobiferus pupæ, 2; Corixa adults, 5; Probezzia glaber, 3; Hyalella, 74.

Station 28; August 24; number examined, 2. Lengths: 187, 142. Food: Micronecta nymph, 1.5; Cænis diminuta nymphs, 2.5; Enallagma antennatum nymphs, 0.5; Sialis larvæ, 2.5; Stratyiomyia discalis larvæ, 2.5; Notonecta nymph, 3.5; Corixa adults, 4.5; Hyalella, 1.5; Physa, 1.5; sponge, 10; Lemna, 7.5; Ceratophyllum, 48.5.

Station 15; October 1; number examined, 1. Length: 160. Food: Chironomus lobiferus larvæ, 35; Leptocella uwarowii adult, 10; Hyalella, 5; crayfish, 12; Valvata tricarinata, 10; Amnicola limosa, 10; Ancylus, 3; plant remains, 5; Vallisneria, 10; Myriophyllum, 2; filamentous algæ, 3.

Grand summary.—Number examined, 9. Length: Maximum, 187; minimum, 116; average, 145.7. Food: Toad? eggs, 9.4; insect larvæ, 11.6; insect pupæ, 0.9; adult insects, 9.3; amphipods, 9; crayfish, 1.3; leeches, 2.8; snails, 25.8; sponge, 2.2; plants, 21.9; algæ, 3.6; fine débris, 2.8.

The food of the pumpkinseed was made up of insects (22.1 per cent), large Crustacea (10.3 per cent), snails (25.8 per cent), plants (25.5 per cent), and other things. Forbes and Richardson (1908) found that more than half the food of the fish they examined was molluscs; the rest was amphipods, isopods, and insects. Hankinson (1908) reported midge larvæ, May-fly nymphs, crayfishes, amphipods, snails, leeches, and caddis-fly larvæ. Reighard (1915) found snails, insect larvæ, and Chara. Insects formed the chief food of those fish examined by Baker (1916).

Fundulus diaphanus menona (Jordan and Copeland). Menona top minnow.

Data for 1914 (Pearse, 1915).—Number examined, 49. Length: Maximum, 49.5; minimum, 27.5; average, 35.4. Food: Dipterous larvæ, 6.1; beetle larvæ, 0.6; hemipterous larvæ, 0.7; dragon-fly nymphs, +; May-fly nymphs, 1.7; podurans, +; insects, 3.2; mites, 1; Hyalella, 16.2; ostracods, 25.2; copepods, 1.2; cladocerans, 27; Planorbis, 0.1; plant remains, 0.1; Wolffia, 14.7; filamentous algæ, 0.1.

Station 17; December 3; number examined, 1. Length: 37. Food: Chironomus viridicollis larvæ, 5; C. viridis larvæ, 5; Chydorus sphæricus, 10; Ceriodpahnia, 40; Eurycercus lamellatus, 40.

Summary.—Food: Chironomid larvæ, 10; cladocerans, 90.

Station 19; December 3; number examined, 1. Length: 38. Food: Cricotopus trifasciatus larvæ, 92; Hyalella, 8.

Station 17; April 6, 1915; number examined, 10. Length: Maximum, 42.1; minimum, 27.9; average, 31.6. Food: Dipterous larvæ, 7; Chironomus tentans larvæ, 5.8; C. fulviventris larvæ, 10; C. decorus larvæ, 8; Corethra larvæ, 6; adult Diptera, 14; ostracods, 6.5; Cyclops, 5.5; Canthocamptus, 2.5; Chydorus sphæricus, 4; oligochætes, 14.3; nematodes, 0.2; unknown eggs, 10; plants, 0.2; algæ, 3; fine débris, 3.

Summary.—Food: Dipterous larvæ, 36.6; adult Diptera, 14; ostracods, 6.5; copepods, 8; cladocerans, 4; oligochætes, 14.3; nematodes, 0.2; unknown eggs, 10; plants, 3.2; fine débris, 3.

Station 17; April 13; number examined, 4. Length: Maximum, 45.5; minimum, 30; average, 39.5. Food: Chironomid larvæ, 5; Chironomus fulviventris larvæ, 0.5; C. decorus larvæ, 0.9; C. lobiferus larvæ, 14.2; ostracods, 15.5; Cyclops, 9.2; Canthocamptus, 3.7; Ceriodaphnia, +; oligochætes, 3.7; nematodes, 1.2; plant remains, 4.2; Wolffia, 10.7; algæ, 1.5; fine débris, 29.2.

Summary.—Food: Chironomid larvæ, 20.6; ostracods, 15.5; copepods, 12.9; oligochætes, 3.7; nematodes, 1.2; plants, 16.4; fine débris, 29.2.

Station 21; April 28; number examined, 10. Length: Maximum, 46; minimum, 27; average, 38.6. Food: Young fish with yolk sacs, 6.9; chironomid larvæ, 0.6; Chironomus fulviventris larvæ, 3.6; C. flavus larvæ, 2; Tanypus decoloratus larvæ, 0.8; Tanytarsus exiguus larvæ, 2; T. dives larvæ, 2; Orthocladius sp. larvæ, 0.4; O. nivoriundus larvæ, 4; Palpomyia longipennis larvæ, 1; Tabanus larvæ, 1.1; podurans, 0.7; midges, 9.2; Dikerogammarus fasciatus, 19.7; Cyclops, 3.1; Canthocamptus, 1.3; Sphæridæ, 4; oligochætes, 1.5; eggs, 1.1; plant remains, 7.2; fine débris, 17.1.

Summary.—Food: Dipterous larvæ, 17.5; adult insects, 9.9; amphipods, 19.7; copepods, 4.4; Sphæridæ, 4; oligochætes, 1.5; eggs, 1.1; plants, 7.2; fine débris, 17.1.

Station 21, along shore of Lake Wingra; April 28; number examined, 10. Length: Maximum, 39; minimum, 33; average, 38. Food: Tanypus decoloratus larvæ, 0.3; T. d. pupæ, 16; Cricotopus trifasciatus pupæ, 1; adult Diptera, 0.5; terrestrial mites, 1.4; ostracods, 46.5; Cyclops, 15.7; Canthocamptus, 1.5; Chydorus sphæricus, 5.1; Eurycercus, 8.1; nematodes, 0.3; algæ, 3.5.

Summary.—Food: Dipterous larvæ, 0.3; dipterous pupæ, 17; adult insects, 0.5; mites, 1.4; ostracods, 46.5; copepods, 17.2; cladocerans, 13.2; nematodes, 0.3; algæ, 3.5.

Station 5; May 12; number examined, 10. Length: Maximum, 59; minimum, 34; average, 47.4. Food: Fish eggs, 4.5; Cricotopus trifasciatus larvæ, 4.4; Chironomus viridis larvæ, 1; C. viridicollis larvæ, 5.6; Tanypus decoloratus larvæ, 2.2; Pelopia monilis larvæ, 1; Orthocladius sordidellus larvæ, 2.5; Probezzia pallida larvæ, 0.1; Cænis diminuta nymphs, 6.4; May-fly nymphs, 0.5; Orthocladius sordidellus pupæ, 2.4; Tanypus decoloratus pupæ, 0.8; Collembola, 0.5; midges, 1; terrestrial mites, 0.8; Hyalella, 3.5; ostracods, 26.2; Cyclops, 5.8; Chydorus sphæricus, 21.2; Eurycercus lamellatus, 2.9; Sphæridæ, 1; Planorbis, 1.2; plant remains, 0.7; algæ, 1.3; fine débris, 0.5.

Summary.—Food: Fish eggs, 4.5; insect larvæ, 20.1; pupæ, 3.2; adult insects, 1.5; mites, 0.8; amphipods, 3.5; ostracods, 26.2; copepods, 5.8; cladocerans, 25.1; molluscs, 2.2; plants, 2; fine débris, 0.5.

Station 16; May 15; number examined, 8. Length: Maximum, 52; minimum, 32; average, 39.5. Food: Helea larvæ, 2; Cricotopus trifasciatus larvæ, 20.7; Tanypus decoloratus larvæ, 0.5; Orthocladius sordidellus larvæ, 5.5; Palpomyia larvæ, 5; Cænis diminuta nymphs, 2.1; Cricotopus trifasciatus pupæ, 5; mites, 3; ostracods, 7; Cyclops, 18.5; Chydorus sphæricus, 2; Pleuroxus procurvatus, 1.5; Planorbis, 11.7; oligochætes, 12; plant remains, 0.2; algæ, 0.1.

Summary.—Food: Insect larvæ, 35.7; pupæ, 5; mites, 3; ostracods, 7; copepods, 18.5; cladocerans, 3.5; snails, 11.7; oligochætes, 12; plants, 0.3.

Station 5; June 1; number examined, 10. Length: Maximum, 49; minimum, 30; average, 38. Food: Beetle larvæ, 6; May-fly nymphs, 1; Helea larvæ, 1; Chironomus decorus larvæ, 2.7; C. lobiferus larvæ, 4.8; Orthocladius sordidellus larvæ, 37.7; Probezzia glaber larvæ, 0.4; C. digitatus pupæ, 0.1; Hyalella, 1.5; ostracods, 12.5; Cyclops, 0.5; Chydorus sphæricus, 3.3; Eurycercus, 5.7; snails, 0.5; Planorbis, 12.5; Limnæa, 9; Physa ,0.8.

Summary.—Food: Insect larvæ, 54.6; pupæ, 0.1; amphipods, 1.5; ostracods, 12.5; copepods, 0.5; cladocerans, 9; snails, 23.2.

Station 6; June 24; number examined, 10. Length: Maximum, 58.8; minimum, 37; average, 48.4. Food: Helea larvæ, 0.5; Chironomus plumosus larvæ, 0.4; C. lobiferus larvæ, 1.2; Orthocladius sordidellus larvæ, 0.5; Probezzia glaber larvæ, 2; Ecdyurus maculipennis nymphs, 16.8; Orthocladius sordidellus pupæ, 0.2; Tanypus monilis pupæ, 0.1; C. decorus pupæ, 0.5; C. digitatus pupa, 1; Corixa adults, 0.4; Hyalella, 30.1; ostracods, 7.9; Cyclops, 2.2; Chydorus sphæricus, 7.9; Pleuroxus procurvatus, 0.2; Planorbis, 14.4; Physa, 5.8; oligochætes, 2.5; fine débris, 5.

Summary.—Food: Insect larvæ, 21.4; pupæ, 1.8; adult insects, 0.4; amphipods, 30.1; ostracods, 7.9; copepods, 2.2; cladocerans, 8.1; snails, 20.2; oligochætes, 2.5; fine débris, 5.

Station 3; June 24; number examined, 10. Length: Maximum, 67.5; minimum, 53; average, 57.9. Food: Insect larva, 1; Helea larvæ, 0.3; Cricotopus trifasciatus larvæ, 1.4; Chironomus plumosus larvæ, 2.1; Tanypus monilis larvæ, 3.6; Orthocladius sordidellus larvæ, 43; Probezzia glaber larvæ, 0.3; P. pallida larvæ, 1.3; Sialis larva, 0.1; Ecdyurus maculipennis nymphs, 8.3; Orthocladius sordidellus pupæ, 0.4; Chironomus digitatus pupæ, 0.2; Hyalella, 11.4; ostracods, 0.3; Cyclops, 0.1; Chydorus, 1; fine débris, 26.

Summary.—Food: Insect larvæ, 61.4; pupæ, 0.6; amphipods, 11.4; ostracods, 0.3; copepods, 0.1; cladocerans, 1; fine débris, 26.

Station 18; July 3; number examined, 11. Length: Maximum, 55; minimum, 41; average, 47.3. Food: Helea larvæ, 0.2; chironomid larvæ, 3; Chironomus lobiferus larvæ, 3.6; C. abbreviatus larvæ, 0.2; Probezzia glaber larvæ, 0.5; Protenthes culiciformis larvæ, 0.3; Procladius sp. larvæ, 19.7; Hyalella, 49.1; Dikerogammarus fasciatus, 0.1; Eurycercus, 22.6; algæ, +.

Summary.—Food: Insect larvæ, 27.5; amphipods, 49.2; cladocerans, 22.6; algæ, +.

Station 23; August 9; number examined, 3. Lengths: 32.5; 30.5; 25.4. Food: Chironomid larvæ, 11.6; Chironomus fulviventris larvæ, 3.3; C. viridis larvæ, 3.3; C. lobiferus larvæ, 6.3; Tanytarsus exiguus larvæ, 6.3; Hyalella, 40; ostracods, 5; Cyclops, 1.3; Chydorus sphæricus, 3.3; Ceriodaphnia, 3.3; Eurycercus, 8.3; oligochætes, 6.3.

Summary.—Food: Insect larvæ, 30.8; amphipods, 40; ostracods, 5; copepods, 1.3; cladocerans, 14.9; oligochætes, 6.3.

Grand summary for 1914 and 1915.—Number examined, 149. Length: Maximum, 67.5; minimum, 25.4; average, 40.4. Food: Fish embryos, 0.8; insect eggs, 0.8; insect larvæ, 23.4; pupæ, 1.7; adult insects, 2.7; mites, 3; amphipods, 14.1; ostracods, 15.7; copepods, 4.9; cladocerans, 15.3; Sphæridæ, 0.4; snails, 3.5; oligochætes, 2; nematodes, +; plant remains, 5.5; algæ, 0.9; silt and débris, 4.2.

The top minnow ate 36 per cent entomostracans and 28 per cent insects, as well as amphipods, plant remains, the débris from the bottom and the surface of plants, molluscs, etc. Forbes and Richardson (1908) reported the food of this species to be insects, amphipods, snails, and plant seeds. The large percentages of ostracods, oligochætes, and Chydoridæ and the species of insect larvæ found in the present investigation indicate that the top minnow frequently feeds near the bottom or among vegetation.

Labidesthes sicculus (Cope). Brook silverside.

Data for 1914 (Pearse, 1915).—Number examined, 50. Length: Maximum, 47.9; minimum, 15.4; average, 35.7. Food: Insect larvæ, 5.1; pupæ and adult insect, 42.4; mites, 0.1; ostracods, +; copepods, 8.1; cladocerans, 27.3; rotifers, +; protozoans, +; plant remains, 2.5; algæ, 8; silt and débris, 3.3.

Station 23; August 11, 1915; number examined, 1. Length: 25.3. Food: Tanytarsus adults, 40; Cyclops, 15; Chydorus sphæricus, 37; Ceriodaphnia, 8.

Station 18; August 14; number examined, 10. Length: Maximum, 27; minimum, 11.5; average, 20.5. Food: Chironomus eggs, 9.5; chironomid larvæ, 5; Probezzia pallida adult, 11.5; ostracods, 0.3; Cyclops, 24.7; Chydorus sphæricus, 0.4; Ceriodaphnia, 37.4; Bosmina, 7.3; Pleuroxus procurvatus, 0.1; Camptocercus, 0.2; ephippial eggs, 3.5.

Summary.—Food: Insect eggs, 9.5; insect larvæ, 5; adult insects, 11.5; ostracods, 0.3; cladocerans, 48.9.

Station 19; August 18; number examined, 9. Length: Maximum, 36; minimum, 22; average, 28.2. Food: Chironomid larvæ, 2.2; Chironomus viridis pupæ, 44.6; C. tentans, pupæ, 5.3; Tanytarsus adult, 2.2; Chironomus viridis adult, 2.7; Cyclops, 5.6; Ceriodaphnia, 37.

Summary.—Food: Insect larvæ, 2.2; pupæ, 49.9; adults, 4.9; copepods, 5.6; cladocerans, 37.

Station 18; August 18; Number examined, 5. Length: Maximum, 33; minimum, 25; average, 28. Food: Corethra larvæ, 0.6; Chironomus viridis adult, 28.8; spider, 0.2; Cyclops, 11; Chydorus, 0.4; Ceriodaphnia, 58; Daphnia hyalina, 1.

Summary.—Food: Insect larvæ, 0.6; adult insects, 28.8; spider, 0.2; copepods, 11; cladocerans, 59.4.

Station 23, west of mouth of Yahara Canal in Lake Monona; August 19; number examined, 5. Length: Maximum, 38.5; minimum, 21.5; average, 31.2. Food: Caterpillar, 1.4; Chironomus viridis pupæ, 23; Tanytarsus adult, 3.5; Chironomus viridis adult, 33; C. digitatus adult, 2.6; C. tentans adult, 6; spider, 5; Cyclops, 0.6; Chydorus, 4.4; Pleuroxus, +; Daphnia hyalina, 20.4.

Summary.—Food: Insect larvæ, 1.4; pupæ, 23; adults, 45.1; spider, 5; copepods, 0.6; cladocerans, 24.8.

Station 24; August 19; number examined, 5. Length: Maximum, 41.5; minimum, 20.5; average, 28. Food: Chironomus viridis larvæ, 5; Chironomus viridis pupæ, 82.8; Chironomus viridis adults, 5.2; C. tentans adults, 3.8; spider, 0.2; Cyclops, 2.6; Chydorus, 0.4.

Summary.—Food insect larvæ, 0.5; pupæ, 82.8; adults, 9; spider, 0.2; copepods, 2.6; cladocerans, 0.4.

Station 23, at mouth of river; August 19; number examined, 5. Length: Maximum, 41.5; minimum, 21.5; average, 31.5. Food: Corethra larvæ, 3; Chironomus viridis pupæ, 45; Tanytarsus adult, 5; Chironomus viridis adult, 6; C. digitatus adult, 21; spider, 1; Cyclops, 1; Ceriodaphnia, 7; Eurycercus, 11.

Summary.—Food: Insect larvæ, 3; pupæ, 45; adults, 32; spider, 1; copepods, 1; cladocerans, 18.

Station 5; August 25; number examined, 4. Length: Maximum, 80.5; minimum, 30.3; average, 54.4. Food: Cyclops, 15.5; Chydorus, 7; Bosmina, 74.4; Camptocercus, 2.2; rotifers, 0.2; Closterium, 0.2.

Summary.—Food: Copepods, 15.5; cladocerans, 83.6; rotifers, 0.2; algæ, 0.2.

Station 6; August 25; number examined, 6. Length: Maximum, 77; minimum, 25.5; average, 41.6. Food: Chironomus viridis pupæ, 52.5; C. tentans pupæ, 14.4; Tanytarsus adult, 2.8; Chironomus viridis adult, 6.6; Cyclops, 3; Ceriodaphnia, 19.6; Bosmina, 1.6.

Summary.—Food: Insect pupæ, 66.9; adults, 9.4; copepods, 3; cladocerans, 21.2.

Grand summary for 1914 and 1915.—Number examined, 100. Length: Maximum, 77; minimum, 11.5; average, 40.9. Food: Insect eggs, 1.4; insect larvæ, 5.2; insect pupæ, 16.4; adult insects, 28.3; spiders, 0.3; mites, +; ostracods, +; copepods, 8.7; cladocerans, 32; rotifers, +; protozoans, +; algæ, 4.

The silverside is more of a "top-minnow" than the top-minnow (*Fundulus diaphanus menona*) itself. The fact that its food contains 44.6 per cent adult insects and pupæ, 40.7 per cent entomostracans, and only a trace of ostracods can be interpreted in no other way. Forbes and Richardson (1908) stated that this species feeds on animal plankton, chironomid larvæ, land insects, and spiders. One fish they examined had eaten a very small minnow. Baker (1916) found the stomachs of the fish he examined to contain a large percentage of insects and small amounts of Crustacea, Acarina and Bryozoa.

Lepisosteus osseus (Linnæus). Long-nosed gar, billfish.

Station 28; September 14, 1915; number examined, 1. Length: 650. Food: Lepomis incisor, 100.

Station 23; September 21; number examined, 1. Length: 218. Food: Lepomis incisor, 98; Simulium vittatum larvæ, 2.

Station at Oconomowoc Lake; number examined, 1. Length: 180. Food: Labidesthes sicculus, 90; Chironomus adults, 10.

Station 22; July 1, 1916; number examined, 5. Length: Maximum, 652; minimum, 480; average, 577. Food: Fish, 40; minnow remains, 40; Enallagma antennatum nymphs, 20.

Station 20; July 3; number examined, 1. Length: 600. Food: Johnny darter, 100.

Station 22; July 8; number examined, 1. Length: 416. Food: Fish, 100.

Summary for 1915 and 1916.—Number examined, 10. Length: Maximum, 652; minimum, 180; average, 494.9. Food: Fish, 88.8; insect larvæ, 10.2; adult insects, 1.

The youngest gars examined fed somewhat on insects and larvæ, but the chief food of all was small fishes. Forbes and Richardson (1908) reported nothing but small fish for the food of this species.

Lepomis incisor Cuvier and Valenciennes. Bluegill, blue sunfish.

Data for 1914 (Pearse, 1915).—Number examined, 49. Average length, 30.8. Food: Insect larvæ, 22.8; adult insects, 26; mites, 1.2; amphipods, 23.1; copepods, 16.4; cladocerans, 31; oligochætes, 0.2; nematodes, +; rotifers, +; plants, 1.3; algæ, 0.4.

Station 13; April 10, 1915; number examined, 7. Length: Maximum, 108; minimum, 53; average, 87.7. Food: Chironomus fulviventris larvæ, 9.9; C. decorus larvæ, 0.4; Leptocella uwarowii larvæ, 0.4; Heptagenia interpunctata larvæ, 0.4; Hyalella, 18.5; Chydorus sphæricus, 0.3; plant remains, 27.1; fine débris, 42.1.

Summary.—Food: Insect larvæ, 11.1; amphipods, 18.5; cladocerans, 0.3; plants, 27.1; fine débris, 42.1.

Station 13; April 13; number examined, 14. Length: Maximum, 105; minimum, 46; average, 80.1. Food: Insect eggs, 0.3; chironomid larvæ, 0.7; Tanypus monilis larvæ, 0.7; Chironomus viridis larvæ, 0.7; C. digitatus larvæ, 4; C. palliatus larvæ, 3.1; C. lobiferus larvæ, 0.7; C. fulviventris larvæ, 2.1; C. decorus larvæ, 2.2; Cricotopus trifasciatus larvæ, 0.2; Orthocladius sordidellus larvæ, 1; Procladius larvæ, 6.2; Hydroptila larvæ, 2.8; Agraylea larvæ, 0.3; May-fly nymphs, 2.3; Heptagenia interpunctata larvæ, 2.4; Enallagma hageni nymphs, 14.2; Chironomus lobiferus pupæ, 0.7; C. tentans pupæ, 0.8; Hyalella, 3.5; ostracods, 0.2; Cyclops, 8; Canthocamptus, 2.7; snail eggs, 5.7; plant remains, 8.5; algæ, 5.3; Aphanothece, 17.1; silt and débris, 2.4.

Summary.—Food: Insect larvæ, 43.6; pupæ, 1.5; amphipods, 3.5; ostracods, 0.2; copepods, 10.7; snail eggs, 5.7; plants, 8.5; algæ, 22.4; silt and débris, 2.4.

Station 21, on south shore of Lake Wingra; April 28; number examined, 1. Length: 27.5. Food: Chironomus lobiferus larvæ, 5; Cyclops, 84; Chydorus sphæricus, 11.

Station 5; May 12; number examined, 5. Length: Maximum, 58; minimum, 32; average, 47.1. Food: Insect larvæ, 1; chironomid larvæ, 15; Chironomus lobifererus larvæ, 1.2; C. decorus larvæ, +; C. fulviventris larvæ, 4; Pelopia monilis larvæ, 0.1; Cricotopus trifasciatus larvæ, 5.9; Corethra larvæ, 6.4; May-fly nymphs, 17; Siphlurus nymphs, 7; chironomid pupæ, 2.4; Cricotopus trifasciatus adults, 5; adult midges, 5; mites, 1.8; Arrhenurus, 2; Hyalella, 24.2; ostracods, 0.7; Eurycercus, 0.8; Chydorus sphæricus, 0.5; algæ, 0.1.

Summary.—Food: Insect larvæ, 56.6; pupæ, 2.4; adult insects, 10; mites, 3.8; amphipods, 24.2; ostracods, 0.7; cladocerans, 1.3; algæ, 0.1.

Station 16; May 15; number examined, 7. Length: Maximum, 56; minimum, 41; average, 48.8. Food: Insect larvæ, 0.7; Cricotopus trifasciatus larvæ, 77.4; Orthocladius sordidellus larvæ, 7; Probezzia pallida larvæ, 0.9; P. glaber larvæ, 0.7; chironomid pupæ, 7; Hyalella, 5.6; ostracods, 0.4; Planorbis, 0.1; algæ, 0.1.

Summary.—Food: Insect larvæ, 86.7; pupæ, 7; amphipods, 5.6; ostracods, 0.4; Planorbis, 0.1; algæ, 0.1.

Station 3; June 4; number examined, 2. Lengths: 115, 117. Food: Helea larvæ, 1.5; chironomid larvæ, 1; Chironomus lobiferus larvæ, 1; Simulium vittatum larvæ, 10; Peltodytes edentulus larvæ, 2.5; Tabanus pupæ, 5; Hyalella, 3.5; ostracods, 0.4; Eurycercus, 52.5; Physa, 0.5; leech, 17.5; plants, 5.

Summary.—Food: Insect larvæ, 16; pupæ, 5; amphipods, 3.5; cladocerans, 52.5; snails, 0.5; leech, 17.5; plants, 5.

Station 23; June 14; number examined, 2. Lengths: 44, 42. Food: Chironomus tentans larvæ, 5; Orthocladius sordidellus larvæ, 5; Chironomus lobiferus pupæ, 5; Orthocladius sordidellus pupæ, 7.5; chironomid pupæ, 4; Hyalella, 73.5.

Summary.—Food: Insect larvæ, 10; pupæ, 16.5; amphipods, 73.5.

Station 2; June 15; number examined, 7. Length: Maximum, 58; minimum, 43.5; average, 50.1. Food: Helea larvæ, 0.4; chironomid larvæ, 3.5; Chironomus fulviventris larvæ, 4.4; Orthocladius sordidellus larvæ, 4.5; Orthocladius sp. larvæ, 1.2; Protenthes monilis larvæ, 1.4; Probezzia pallida larvæ, 2.5; caddis-fly larva and case, 1.4; Cænis diminuta nymphs, 13; Callibætis nymphs, 11; Enallagma hageni nymphs, 9; E. antennatum nymphs, 1; Chironomus lobiferus pupæ, 17; mites, 1; Hyalella, 16; ostracods, 2; Cyclops, 2; Eurycercus, 1; Chydorus, 0.1; ephippial eggs, 0.1; Planorbis, 6.8.

Summary.—Food: Insect larvæ, 53.3; pupæ, 17; mites, 1; amphipods, 16; ostracods, 2; copepods, 2; cladocerans, 1.2; snails, 6.8.

Station 27; June 17; number examined, 8. Length: Maximum, 124; minimum, 69; average, 100.9. Food: Chironomus lobiferus larvæ, 13.1; Palpomyia longipennis larvæ, 8; Orthocladius sordidellus larvæ, 12; Probezzia pallida larvæ, 10.2; caddis-fly larvæ in cases, 7.2; Chironomus lobiferus pupæ, 15; Orthocladius sordidellus pupæ, 9.8; Palpomyia longipennis pupæ, 1; Probezzia pallida pupæ, 0.2; adult midges, +; Corixa adults, 11.4; Camponotus adult, 0.1; mites, 0.2; Lebertia, 2; Hyalella, 8.1; ostracods, 0.1; Eurycercus, 2.5.

Summary.—Food: Insect larvæ, 50.5; pupæ, 26; adult insects, 11.5; mites, 2.2; amphipods, 8.1; ostracods, 0.1; cladocerans, 2.5.

Station 28; June 17; number examined, 10. Length: Maximum, 83; minimum, 39.5; average, 58.9. Food: Insect larvæ, 0.5; Chironomus tentans larvæ, 5.8; C. lobiferus larvæ, 1.4; Orthocladius sordidellus larvæ, 26; Probezzia pallida larvæ, 1.5; Corethra larvæ, 0.5; May-fly nymphs, 3.6; Ecdyurus maculipennis nymphs, 11.5; Cænis diminuta nymphs, 3.5; Enallagma antennatum nymphs, 2; chironomid pupæ, 5; Chironomus lobiferus pupæ, 1.1; C. tentans pupæ, 0.2; Orthocladius sordidellus pupæ, 20.9; Corixa adults, 10.7; mites, 0.2; Cyclops, 0.5; Eurycercus lamellatus, 4.8; Camptocercus, 0.1.

Summary.—Food: Insect larvæ, 55.7; pupæ, 27.2; adult insects, 10.7; mites, 0.2; copepods, 0.5; cladocerans, 4.9.

Station 3; June 24; number examined, 10. Length: Maximum, 68.5; minimum, 44; average, 54.8. Food: Tanypus monilis, 1.6; Chironomus tentans larvæ, 6.3; C. digitatus larvæ, 0.4; C. lobiferus larvæ, 14; Palpomyia longipennis larvæ, 4.5; Orthocladius sordidellus larvæ, 25.8; Probezzia pallida larvæ, 13.8; Leptocella larva and case, 2.8; May-fly nymphs, 2.3; Ecdyurus nymphs, 6.2; Peltodytes edentulus larvæ, 0.3; Chironomid pupæ, 1.5; Chironomus digitatus pupæ, 0.5; Orthocladius sordidellus pupæ, 3.4; Probezzia pallida pupæ, 0.7; sawfly adult, 0.2; Chironomus lobiferus adults, 7.7; mites, 0.1; Hyalella, 0.9; ostracods, 0.1; Eurycercus, 0.3; Planorbis, 5.2; Physa, 0.3.

Summary.—Food: Insect larvæ, 78; pupæ, 6.1; adult insects, 7.9; amphipods, 0.9; ostracods, 0.1; cladocerans, 0.3; snails, 5.5.

Station 18; July 3; number examined, 10. Length: Maximum, 65; minimum, 33.8; average, 45.4. Food: Tanypus monilis larvæ, 0.3; Chironomus viridis larvæ, 0.3; C. digitatus larvæ, 4.4; C. palliatus larvæ, 6.3; Cricotopus trifasciatus larvæ, 0.2; Orthocladius sordidellus larvæ, 3.4; Procladius larvæ, 12; May-fly nymphs, 0.2; Peltodytes edentulus larvæ, 0.2; C. lobiferus pupæ, 2.7; C. tentans pupæ, 1.2; mites, 3.2; Hyalella, 9.8; cladocerans, 8.4; Eurycercus, 47.1.

Summary.—Food: Insect larvæ, 27.3; pupæ, 3.9; mites, 3.2; amphipods, 9.8; cladocerans, 55.5.

Station 23; July 9; number examined, 5. Length: Maximum, 80; minimum, 54; average, 65.7. Food: Insect larvæ, 15; Chironomus tentans larvæ, 4.2; C. fulviventris larvæ, 3.4; Leptocella uwarowii larvæ, 3.6; May-fly nymphs, 0.4; chironomid pupa, 12; Chironomus viridis pupæ, 0.6; Corixa adults, 2; leaf-hopper, 2; mites, 0.2; Hyalella, 19.4; Physa, 28.2; leech, 11.

Summary.—Food: Insect larvæ, 26.6; pupæ, 12.6; adult insects, 4; mites, 0.2; amphipods, 19.4; snails, 28.2; leech, 11.

Station 13; July 23; number examined, 2. Lengths: 60, 37. Food: Insect larvæ, 1; Probezzia glaber larvæ, 25; chironomid larvæ, 1; C. tentans larvæ, 3; C. lobiferus larvæ, 12; Probezzia glaber pupæ, 2.5; Hyalella, 44; Chydorus sphæricus, 1.5; Physa, 32.5.

Summary.—Food: Insect larvæ, 19.5; pupæ, 2.5; amphipods, 44; cladocerans, 1.5; snails, 32.5.

Station 23; July 23; number examined, 3. Lengths: 73, 71, 65. Food: Chironomus viridis larvæ, 11.3; C. vulviventris larvæ, 37.6; C. tentans larvæ, 8.3; Pelopia monilis larvæ, 6; Probezzia glaber larvæ, 0.6; Hydroptila larvæ, 0.3; Simulium vittatum larvæ, 1.6; Peltodytes edentulus larvæ, 0.6; Chironomus viridis pupæ, 4.3; Arrhenurus, 0.1; Hyallela, 5; Ancylus, 0.3; Planorbis, 0.3; Physa, 21.6; snail eggs, 0.6.

Summary.—Food: Insect larvæ, 66.3; pupæ, 4.3; mites, 0.1; amphipods, 5; snails, 22.8.

Station 7, in swamp along shore; August 25; number examined, 4. Lengths: 30, 27.5, 17.8, 15. Food: Tanypus monilis larvæ, 3.7; Cænis diminuta nymphs, 1.2; Corixa adult, 1.2; Cyclops, 30.1; Canthocamptus, 2.5; Bosmina longirostria cornuta, 28.4; Camptocercus, 5; Eurycercus, 20; algæ, 9.

Summary.—Food: Insect larvæ, 4.9; adult insects, 1.2; copepods, 30.1; cladocerans, 53.4; algæ, 9.

Grand summary for 1914 and 1915.—Number examined, 149. Length: Maximum, 115; minimum, 15; average, 51.1. Food: Insect larvæ, 38; pupæ, 6; adult insects, 2.2; mites, 0.7; aquatic isopods, +; amphipods, 14.4; ostracods, 0.4; copepods, 7.9; cladocerans, 16.6; gastropods, 4.5; oligochætes, 0.1; leeches, 0.6; nematodes, +; rotifers, +; plants, 2.9; algæ, 2.3; silt and débris, 2.2.

The bluegill feeds mostly on insects (46.2 per cent) and entomostracans (24.9 per cent). Its shape and its food indicate that it feeds much among water plants. Forbes and Richardson (1908) found the food to consist of a trace of fishes, some snails, 45 per cent insects, and many medium-sized crustaceans. They state that this species eats more large insect larvæ than any other sunfish. Hankinson (1908), found insect larvæ, midges, and crayfish; after the middle of May, crayfishes, grasshoppers, crickets, beetles, and entomostracans. Reighard (1915) found the bluegill only in shallow water among vegetation. Its food was plants, bryozoans, insects, mites, and ostracods.

Micropterus dolomieu Lacépède. Smallmouth black bass.

Data for 1914 (Pearse, 1915).—Stations 19 and 24; number examined, 2. Lengths: 78, 59. Food: Dipterous larvæ, 10; adult Diptera, 5; Corixa, 85.

Station 28; August 19, 1915; number examined, 1. Length: 181. Food: Minnow, 40; Chironomus lobiferus larvæ, 5; Corixa adults, 15; plant remains, 5; algæ, 10; silt and débris, 25.

Station 24; August 19; number examined, 3. Lengths: 175, 148, 132. Food: Fish remains, 29.9; Lepomis incisor, 30; May-fly nymphs, 5; Corixa adults, 32.6; plant remains, 1.3; filamentous algæ, 1.

Station 12; August 20; number examined, 8. Length: Maximum, 48.5; minimum, 29; average, 36. Food: Chironomus digitatus larvæ, 20; Bætisca nymphs, 22.5; Cænis diminuta nymphs, 0.3; Ecdyurus maculipennis nymphs, 9; Chironomus lobiferus pupæ, 2: C. digitatus pupæ, 7; C. flavescens adults, 5.6; Limnephilus adult, 2; Corethra adult, 17; Daphnia longispina hyalina, 4; Eurycercus lamellatus, 0.2; Ceriodaphnia, 1.8; Bosmina, +; oligochætes, 8.6.

Summary.—Food: Insect larvæ, 51.8; pupæ, 9; adult insects, 25.2; cladocerans, 6; oligochætes, 8.6.

Station 14; August 31; number examined, 1. Length: 33.5. Food: Protenthes culiciformis larvæ. 40; Chironomus viridis pupæ, 18; C. lobiferus pupæ, 19; Tanytarsus monilis pupæ, 18; Eurycercus, 5.

Summary.—Food: Insect larvæ, 40; pupæ, 55; cladocerans, 5.

Grand summary for 1914 and 1915.—Number examined, 15. Length: Maximum, 181; minimum, 29; average, 72.5. Food: Fish, 14.7; insect larvæ, 33.1; pupæ, 7.6; adult insects, 32.1; cladocerans, 3.4; oligochætes, 4.6; plants, 0.6; algæ, 0.8; silt and débris, 1.5.

The food of the young smallmouth black bass apparently consists largely of insects and their larvæ. Adults eat fish, crayfish, frogs, and plants as well. Forbes and Richardson (1908) examined only three specimens and found one-third fishes and two-thirds crayfishes. Tracy (1910) reports small fish, insects and their larvæ, and crustaceans. Reighard (1915) examined eight and found crayfish, a frog, and fishes.

Micropterus salmoides Lacépède. Largemouth black bass.

Data for 1914 (Pearse, 1915).—Number examined, 25. Length: 64.4. Food: Fish, 17.8; insect larvæ, 31.6; adult insects, 40.6; Hyalella, 3.8; copepods, +; cladocerans, 2.5; plants, 1.6.

Station 71; April 17, 1915; number examined, 1. Length: 225. Food: Fish 95; leech, 5.

Station 17; April 25; number examined, 1. Length: 470. Food: Ostracods, 0.1; diatoms, 0.4; Aphanothece, 20; filamentous algæ, 24.5; plant remains, 50; débris, 5.

Summary.—Food: Ostracods, 0.1; algæ, 44.9; plant remains, 50; débris, 5.

Station 3; June 24; number examined, 1. Length: 81. Food: Ecdyurus maculipennis nymphs, 10; Enallagma antennatum nymphs, 20; dipterous adult, 5; Corixa adult, 30; crayfish, 20; Hyalella, 15.

Station 23; July 9; number examined, 3. Lengths: 32, 30.3, 29.5. Food: Chironomid larvæ, 10; Chironomus fulviventris larvæ, 6.3; C. tenellus larvæ, 17; C. tentans larvæ, 0.6; May-fly nymphs, 1; Dytiscus hybridus larvæ, 5; Chironomus tenellus pupæ, 16; adult midges, 6.6; Simulium vitattum adults, 8.3; Cyclops, 20; Chydorus sphæricus, 2; ephippial eggs, 0.2; oligochætes, 6.6; Oscillaria, 0.3.

Summary.—Food: Insect larvæ, 39.9; pupæ, 16; adult insects, 8.3; copepods, 20; cladocerans, 2.2; oligochætes, 6.6; algæ, 0.3.

Station 23; July 12; number examined, 1. Length: 33. Food: Chironomus fulviventris larvæ, 35; Anax junius nymphs, 8; C. fulviventris pupæ, 20; Corixa adult, 7; oligochætes, 30.

Station 5; August 9; number examined, 1. Length: 41.6. Food: May-fly nymphs, 65; Hyalella, 35.

Station 17; August 23; number examined, 1. Length: 147. Food: Adult dragon fly, 100.

Station 23, in pool in Tenney Park; August 11; number examined, 1. Length: 62. Food: Cyclops, 65; Simocephalus, 10; Eurycercus lamellatus, 25.

Station 3; August 18; number examined, 12. Length: Maximum, 62; minimum, 38.3; average, 50.8. Food: Chironomus fulviventris larvæ, 0.3; Bætisca nymphs, 23.2; Cænis diminuta nymphs, 3.6; Corixa nymphs, 1.1; C. lobiferus pupæ, 0.8; Corixa adults, 30; Micronecta adult, 0.4; Hyalella, 25; ostracods, 0.3; Eurycercus lamellatus, 12.4; ephippial eggs, 1.2; seeds, 0.2.

Summary.—Food: Insect larvæ, 29.4; pupæ, 0.8; adult insects, 30.4; Hyalella, 25; ostracods, 0.3; cladocerans, 13.6; plants, 0.2.

Station 5; August 18; number examined, 3. Lengths: 68.5, 58, 49.5. Food: May-fly nymphs, 20; Corixa adults, 55; Hyalella, 25.

Station 18; August 18; number examined, 15. Length: Maximum, 64; minimum, 36; average, 46.4. Food: Fish remains, 5.3; chironomid larvæ, 0.6; Chironomus viridis larvæ, 1; Protenthes choreus larvæ, 1.3; Corethra larvæ, 1.3; May-fly nymphs, 0.6; Bætisca nymphs, 4.3; Naucoris nymphs, 2.4; Corixa nymph, 0.6; Chironomus viridis pupæ, 3; adult midges, 3.3; adult Diptera, 2; Chironomus viridis adults, 2.3; adult Corixas, 0.6; Halictus adults, 0.6; Platyphylax subfasciatus adults, 4; Hyalella, 17; ostracods, 0.3; Diaptomus, 0.4; Cyclops, 7.5; Ceriodaphnia, 21.6; Eurycercus, 0.4; Daphnia longispina hyalina, 18.6; Bosmina, +; Pleuroxus, +; Camptocercus, 0.3; Scapholeberis, +; Aphanothece, 0.3.

Summary.—Food: Fish remains, 5.3; insect larvæ, 12.1; pupæ, 3; adult insects, 7.4; amphipods, 17; ostracods, 13; cladocerans, 40.9; algæ, 0.3.

Station 8; August 20; number examined, 5. Length: Maximum, 64; minimum, 47; average, 52.6; Food: Probezzia glaber larvæ, 0.2; Bætisca nymphs, 12; Ecdyurus maculipennis nymphs, 0.8; Enallagma antennatum nymphs, 1; Naucoris nymph, 1; Corixa adults, 30.8; Agraylea multipunctata adult, 1; Leptid adult, 7; Tabanid fly, 3; Hyalella, 29.8; Ceriodaphnia, 8.6; Eurycercus, 4.4; Aplexa hypnorum, 0.4.

Summary.—Food: Insect larvæ, 14; adult insects, 41.8; amphipods, 29.8; cladocerans, 13; snail, 0.4.

Station 14; August 31; number examined, 3. Lengths: 44, 42.6, 42. Food: Bætisca nymphs, 15; Cænis diminuta nymphs, 3.3; Chironomus adults, 6.6; Agraylea multipunctata adults, 13.3; Hyalella, 26.3; Chydorus sphæricus, 1.6; Ceriodaphnia, 33; chydorid, 0.3; Camptocercus, 0.3.

Summary.—Food: Insect larvæ, 18.3; adult insects, 19.9; amphipods, 26.3; cladocerans, 35.2.

Station 1; September 1; number examined, 2. Lengths: 46, 38. Food: Bætisca nymphs, 16.5; chironomid pupæ, 1.5; Chironomus viridis pupæ, 6; C. v. adults, 6.5; Hyalella, 1.5; ostracods, 0.5; Chydorus, 1; Simocephalus, 41.5; Eurycercus, 25.

Summary.—Food: Insect larvæ, 16.5; pupæ, 2.1; adult insects, 6.5; amphipods, 1.5; ostracods, 0.5; cladocerans, 67.5.

Station 29; November 16; number examined, 3. Lengths: 338, 327, 270. Food: Frog, 6.6; fish, 33.3; crayfish, 60.

Grand summary for 1914 and 1915.—Number examined, 78. Length: Maximum, 470; minimum, 29.5; average, 66.8. Food: Frogs, 0.2; fish, 8.7; insect larvæ, 23; pupæ, 3.1; adult insects, 28.1; crayfishes, 2.6; amphipods, 13.9; ostracods, 0.1; copepods, 2.9; cladocerans, 15.1; snails, +; oligochætes, 0.7; leech, +; plant remains, 1.2; algæ, 0.7; fine débris, 0.1.

The largemouth black bass feeds more on insects and their larvæ (34.2 per cent) than anything else, though amphipods (13.9 per cent), entomostracans (18.1 per cent), and fish (8.7 per cent) are also taken in considerable quantities. Young individuals eat more small insects and entomostracans than adults. The largest bass examined ate nothing but fish, crayfish, and frogs. Forbes and Richardson (1908) found the food of this species to consist of fish and crayfishes. Hankinson (1908) stated that crayfishes and insect larvæ are the most important foods. Tracy (1910) mentioned small fish, crayfishes, frogs, insects, and all other aquatic animals of suitable size. Reighard (1915) found perch and crayfish in those he examined.

Notropis heterodon (Cope). Shiner, minnow.

Data for 1914 are not reliable and therefore not included in this paper.

Station 17; April 6, 1915; number examined, 10. Lengths: Maximum, 49.6; minimum, 18.7; average, 34.4. Food: Pelopia larvæ, 2.5; Chironomus larvæ, 13; adult midges, 13; ostracods, 1; Cyclops and nauplii, 19.5; Camptocamptus, 4.5; Chydorus, 6.5; cyst, 0.5; rotifers, 9.3; plant remains, 2; filamentous algæ, 10; Pleurococcus, 5.9; desmids and diatoms, 0.1; fine débris, 11.2.

Summary.—Food: Insect larvæ, 16; adult insects, 13; ostracods, 1; copepods, 24; cladocerans, 6.5; rotifers, 9.3; plants, 2; algæ, 16; fine débris, 11.2.

Station 17; April 7; number examined, 7. Length: Maximum, 50; minimum, 24.5; average, 34.7. Food: Chironomus larvæ, 1.4; adult midges, 2; mites, 10; ostracods, 3; Cyclops, 33; Canthocamptus, 8; Chydorus, 4; cladocerans, 1.4; ephippial eggs, 4.7; rotifers, 12; Pandorina, 0.6; plant remains, 7; Wolffia, 10; filamentous algæ, 3.1; desmids and diatoms, 0.1; fine débris, 8.2.

Summary.—Food: Insect larvæ, 1.4; adult insects, 2; mites, 1.4; ostracods, 3; copepods, 41; cladocerans, 10.1; rotifers, 12; plants, 17; algæ, 3.8; débris, 8.2.

Station 5; May 12; number examined, 8. Length: Maximum, 47.5; minimum, 28.6; average, 36.3. Food: Chironomus larvæ, 2.5; Camptocercus, 0.1; Chydorus, 27.8; cladocerans, 1.2; plant remains, 1; filamentous algæ, 49.5; fine débris, 17.7.

Summary.—Food: Insect larvæ, 2.5; cladocerans, 29.1; plants, 1; algæ, 49.5; débris, 17.7.

Station 16; May 15; number examined, 6. Length: Maximum, 54; minimum, 26; average, 31.9. Food: Insect eggs, 8; Orthocladius sordidellus larvæ, 6.6; Chironomus larvæ, 14.1; ostracods, 0.5; Cyclops, 11.6; Canthocamptus, 20.5; Pleuroxus, +; Chydorus, 0.1; oligochætes, 29.1; Oscillaria, 3.3; desmids and diatoms, 4.5.

Summary.—Food: Insect larvæ, 28.7; ostracods, 0.5; copepods, 32.1; cladocerans, 0.1; oligochætes, 29.1; algæ, 7.8.

Station 5; June 1; number examined, 1. Length: 47.5. Food: Chironomus larvæ, 85; Cyclops, 9; chydorids, 6.

Station 5; June 24; number examined, 9. Length: Maximum, 42.6; minimum, 32.2; average, 36.2. Food: Orthocladius sordidellus larvæ, 2.5; Tanytarsus dives larvæ, 2.5; Chironomus larvæ, 0.1; C. tentans larvæ, 10; Heptagenia interpunctata larvæ, 6.1; Orthocladius sordidellus pupæ, 21.5; Chironomus pupæ, 11.1; Tanytarsus dives adults, 1.6; Hydroptilus undulatus adults, 4.3; Stenelmis crenatus adult, 2.6; ephippial eggs, 2.2; Wolffia, 14; sand, 21.5.

Summary.—Food: Insect larvæ, 21.2; pupæ, 32.6; adult insects, 8.5; cladocerans, 2.2; plants, 14; sand, 21.5.

Station 19; July 3; number examined, 11. Length: Maximum, 45; minimum, 35; average, 39.9. Food: Chironomus lobiferus larvæ, 3.4; Cricotopus trifasciatus larvæ, 4.5; adult insects, 1.3; mites, 1; Eurycercus, 5; Bosmina, 1; Ceriodaphnia, 0.5; Daphnia longispina hyalina, 42.6; Daphnia, 5.4; Pleuroxus, 0.1; Chydorus, 13.5; chydorids, 1.4; Wolffia, 3.2; filamentous algæ, 16.8.

Summary.—Food: Insect larvæ, 7.9; adult insects, 1.3; mites, 1; cladocerans, 69.5; plants, 3.2; algæ, 16.8.

Station 18; August 18; number examined, 8. Length: Maximum, 49; minimum, 24; average, 35.7. Food: Chironomus larvæ, 0.6; Corethra adults, 6.3; Triænodes flavescens adults, 5.6; sapromyzid fly, 2; Ceriodaphnia, 25.5; Daphnia longispina hyalina, 58.8; Chydorus sphæricus, 1.2.

Summary.—Food: Insect larvæ, 0.6; adult insects, 13.9; cladocerans, 85.5.

Station 18; August 21; number examined, 10. Length: Maximum, 30.5; minimum, 16.8; average, 24.5. Food: Chironomus larvæ, 1; Corethra adults, 7; Chironomus tantans adults, 6; C. viridis adults, 25; Probezzia glaber adults, 6.2; chalcid fly, 4.3; Hyalella, 0.8; Cyclops, 8.5; Camptocercus, 1; Bosmina, 5.5; Ceriodaphnia, 27; Daphnia longispina hyalina, 3; ephippial eggs, 3.5; Hydrodictyon, 1.2.

Summary.—Food: Insect larvæ, 1; adult insects, 48.5; amphipods, 0.8; copepods, 8.5; cladocerans, 39; algæ, 1.2.

Station 17; August 23; number examined, 10. Length: Maximum, 33; minimum, 19.8; average, 24.5. Food: Probezzia larvæ, 2.5; Chironomus lobiferus larvæ, 33.3; parnid larvæ, 0.3; hemipterous nymph, 1; Chironomus pupæ, 2; Tanytarsus dives adults, 1; mites, 2.4; ostracods, 0.5; Cyclops, 7.8; Canthocamptus, 0.5; Acroperus, 0.2; Camptocercus, 0.4; Bosmina, 0.5; Simocephalus, 41.2; Chydorus, 3.9; oligochætes, 2.

Summary.—Food: Insect larvæ, 36.1; pupæ, 1.2; adult insects, 1; mites, 2.4; ostracods, 0.5; copepods, 8.3; cladocerans, 46.2; oligochætes, 2.

Grand summary.—Number examined, 80. Length: Maximum, 54; minimum, 16.8; average, 34. Food: Insect eggs, 0.7; insect larvæ, 12.8; pupæ, 4; adult insects, 9.2; mites, 0.5; amphipods, 0.1; ostracods, 0.5; copepods, 11; cladocerans, 33.4; oligochætes, 2.1; rotifers, 2.2; plants, 3.9; algæ, 11.7; débris, 4.1; sand, 2.4.

The food of this minnow consists for the most part of entomostracans (44.9 per cent), aquatic plants and algæ (15.6 per cent), and insects (26.7 per cent). The sparcity of ostracods and oligochætes indicates that it does not feed on the bottom. The abundance of Canthocamptus, chydordis, algæ, and rotifers make it probable that the food is secured among aquatic vegetation. Forbes and Richardson (1908) found the food to be mostly entomostracans, also insect larvæ, amphipods, flowers, seeds, and algæ. Hankinson (1908) reported adult midges, algæ, and a few entomostracans.

Perca flavescens (Mitchill). Yellow perch, ring perch, American perch.

Data for 1914 (Pearse, 1915).—Number examined, 16. Average length: 92.5. Food: Insect larvæ, 19.5; adult insects, 2.7; mites, 0.5; Hyalella, 32.8; ostracods, 0.3; copepods, 0.2; cladocerans, 36.6.

Station 6; June 24, 1915; number examined, 10. Length: Maximum, 127; minimum, 76; average, 111.4. Food: Fish eggs, 3; Chironomus plumosus larvæ, 0.3; C. lobiferus larvæ, 2.5; Orthocladius larvæ, 8; Cricotopus trifasciatus larvæ, 1.5; Probezzia larvæ, 1.2; Enallagma antennatum nymphs, 0.5; Cænis diminuta larvæ, 4.1; Heliopsyche borealis larvæ, 5.1; Leptocella uwarowii larvæ, 11; Agraylea larvæ, 0.1; Cricotopus trifasciatus pupæ, 0.4; Chironomus pupæ, 0.2; C. lobiferus pupae, 1; mites, 0.2; Hyalella, 40.6; Planorbis, 0.8; Sphæridæ, 0.8; oligochætes, 3; seeds, 0.1; plant remains, 2.5; fine débris, 7.

Summary.—Food: Insect larvæ, 43.3; pupæ, 1.6; mites, 0.2; amphipods, 40.6; snails, 0.8; clams, 0.8; oligochætes, 3; plants, 2.6; débris, 7.

Station 5; August 18; number examined, 2. Lengths: 135, 113.5. Food: Cænis diminuta larvæ, 10; Bætisca larvæ, 5; Chironomus adult, 2.5; Corixa adults, 51.5; Hyalella, 30.7; Arcella, 0.1; filamentous algæ, 0.3.

Summary.—Food: Insect larvæ, 15; adult insects, 54; amphipods, 30.7; protozoans, 0.1; filamentous algæ, 0.3.

Station 15; August 21; number examined, 2. Lengths: 138, 132. Food: Daphnia longispina hyalina, 100.

Station 17; August 23; number examined, 10. Length: Maximum, 187; minimum, 123; average, 156.5. Food: Tadpoles, 3.5; Chironomus digitatus larvæ, 1.1; C. tentans larvæ, 2.5; C. modestus larvæ, 1; Palpomyia longipennis larvæ, 0.2; Aeschna umbrosa nymphs, 12; Enallagma hageni nymphs, 9.6; Celithemis eponina nymphs, 1.8; Cænis diminuta nymphs, 3.4; Bætisca nymphs, 25.6; neuropteron larvæ, 2.2; Chironomus digitatus pupæ, 2.4; Gryllus nymphs, 0.1; Corixa adults, 4; Dytiscid beetle, 0.3; Naucoris adult, 0.1; Scirtes adult, 0.2; Hyalella, 8.3; ostracods, 0.1; Cyclops, +; Eurycercus, 0.1; Planorbis, 2.2; Physa, 17.1; Arcella, 0.1; fine débris, 1.

Summary.—Food: Insect larvæ, 63.9; pupæ, 2.6; adult insects, 4.6; amphipods, 8.3; ostracods, 0.1; cladocerans, 0.1; snails, 19.3; protozoans, 0.1; débris, 1.

Station 18; August 18; number examined, 3. Lengths of each: 100. Food: Chironomus lobiferus larvæ, 1.1; C. digitatus larvæ, 1.2; Probezzia larvæ, 0.3; Bætisca nymphs, 1.3; Chironomus digitatus pupæ, 2; Triænodes flavescens adults, 1; mites, 1.6; Hyalella, 90.8; Cyclops, 0.1; filamentous algæ, 0.3.

Summary.—Food: Insect larvæ, 3.9; pupæ, 2; adult insects, 1; mites, 1.6; amphipods, 90.8; copepods, 0.1; algæ, 0.3.

Station 18; September 22; number examined, 2. Lengths: 146, 180. Food: Fish, 80; Hyalella, 17.5; Myriophyllum, 5.

Station 15; October 2; number examined, 1. Length: 124. Food: Daphnia longispina hyalina, 95; D. pulex, 5.

Station 29; October 11; number examined, 2. Lengths: 63.5, 63.5. Food: Chironomus lobiferus larvæ, 15.5; C. decorus larvæ, 25; Enallagma antennatum nymph, 40; ostracods, 1; Cyclops, 2.5; Daphnia pulex, 7.5; oligochætes, 7.5; diatoms, 1.

Summary.—Food: Insect larvæ, 80.5; ostracods, 1; copepods, 2.5; cladocerans, 7.5; oligochætes, 7.5; algæ, 1.

Station 26; December 4; number examined, 8. Length: Maximum, 280; minimum, 245; average, 265. Food: Fish, 10; Chironomus decorus larvæ, 84; Sialis larvæ, 5.6.

Station 28; May 30, 1916; number examined, 5. Length: Maximum, 229; minimum, 160; average, 186. Food: Fish eggs, 0.2; Chironomus lobiferus larvæ, 5.4; C. sp. larvæ, 3.2; Enallagma hageni nymphs, 16.4; Atax turgidus nymphs, 1; Corixa sp. nymphs, 17.6; Chironomus sp. pupæ, 7; Hyalella, 15.6; ostracods, 0.2; Physa, 4; filamentous algæ, 11.6; plant remains, 3; mud, 7.6; débris, 3.

Summary.—Food: Fish eggs, 0.2; insect larvæ, 43.6; insect pupæ, 7; amphipods, 15.6; ostracods, 0.2; Mollusca, 4; algæ, 11.6; plants, 3; débris, 10.6.

Station in Oconomowoc Lake; June 14; number examined, 13. Length: Maximum, 67; minimum, 54; average, 57.8. Food: Chironomus sp. larvæ, 8.4; Probezzia glaber larvæ, 3.4; Procladius sp. larvæ, 0.3; Enallagma antennatum nymphs, 7; Chironomus sp. pupæ, 4.7; Hyalella, 18.7; ostracods, 0.3; Cyclops, 32.7; Daphnia, 18.8; Chydorus sphæricus, 2.3; Eurycercus, 0.5; Physa, 0.6; filamentous algæ, 1.4.

Summary.—Food: Insect larvæ, 19.1; insect pupæ, 4.7; amphipods, 18.7; entomostracans, 54.6; Mollusca, 0.6; algæ, 1.4.

Station 16; June 30; number examined, 10. Length: Maximum, 173; minimum, 139; average, 149.6. Food: Chironomus sp. larvæ, 7; Pelocaris femoratus larvæ, 2; Stratiomyia sp. larvæ, 1; Enallagma antennatum nymphs, 4.1; Enallagma hageni nymphs, 5.5; Atax turgidus nymphs, 1.5; Corixa sp. nymphs, 30.6; Limnesia, 0.7; Hyalella, 5; Cyclops, 0.2; Eurycercus, 17; Physa, 5; snails, 16.2; plant remains, 4.9; débris, 0.5.

Summary.—Food: Insect larvæ, 51.7; mite, 0.7; amphipods, 5.; entomostracans, 17.2; Mollusca, 21.2; plants, 4.9; débris, 0.5.

Station 17; July 7; number examined, 10. Length: Maximum, 33; minimum, 25; average, 29.6. Food: Chironomus fulviventris larvæ, 1.6; Tanypus decoloratus larvæ, 6.9; Plea minutissima larvæ, 0.1; Corixa sp. nymphs, 1.5; Chironomid adult, 0.1; Hyalella, 15.3; ostracods, 0.1; Cyclops viridis, 2.9; Cyclops, 40.4; Nauplii, 2.7; Daphnia, 0.1; Chydorus sphæricus, 8.9; Eurycercus, 11.8; Acroperus, 0.2; Ceriodaphnia, 0.1; Pleuroxus procurvatus, 0.5; Bosmina, 6.5.

Summary.—Food: Insect larvæ, 10.1; adult insects, 0.1; amphipods, 15.3; Entomostraca, 74.2.

Station 17; July 19; number examined, 9. Length: Maximum, 38.5; minimum, 34; average, 36.8. Food: Chironomus fulviventris larvæ, 9.1; Chironomus sp. larvæ, 1.1, Procladius sp. larvæ, 0.9; Cricotopus trifasciatus larvæ, 3.7; May-fly nymphs, 5.5; Hyalella, 55.4; ostracods, 2.5; Cyclops, 0.2; Chydorus sphæricus, 0.7; Eurycercus, 17.2; Ceriodaphnia, 4.6; Pleuroxus procurvatus, 0.3.

Summary.—Food: Insect larvæ, 20.3; amphipods, 55.4; Entomostraca, 25.5.

Station 18; August 7; number examined, 10. Length: Maximum, 54.5; minimum, 45.6; average, 50.4. Food: Chironomus fulviventris larvæ, 16.2; May-fly nymphs, 24.9; Enallagma antennatum nymphs, 4.5; Corixa sp. adult, 0.3; Hyalella, 39.6; ostracods, 0.8; Cyclops, 0.4; Daphnia, 0.5; Ceriodaphnia, 13.9; filamentous algæ, 0.9; plant remains, 0.2.

Summary.—Food: Insect larvæ, 45.6; adult insects, 0.3; amphipods, 39.6; Entomostraca, 15.6; algæ, 0.9; plants, 0.2.

Station 18; September 13; number examined, 2. Length: Maximum, 185; minimum, 182, average, 183.5. Food: Minnow remains, 50; Daphnia, 50.

Grand summary for 1914, 1915, and 1916.—Number examined, 115. Length: Maximum, 280; minimum, 25; average, 99.9. Food: Tadpoles, 0.3; fish eggs, 3; insect larvæ, 34.7; insect pupæ, 1.7; adult insects, 1.8; mites, 0.1; amphipods, 24.5; Entomostraca, 25.8; molluscs, 3.8; oligochætes, 0.4; protozoans, +; plant remains, 0.8; algæ, 0.7; silt and débris, 1.1.

The perch apparently feeds mostly on insects (38.2 per cent), amphipods (24.5 per cent), and entomostracans (25.8 per cent). Even large adults often have nothing in the alimentary canal except a great number of cladocerans. Forbes and Richardson (1908) stated that the perch is wholly carnivorous. Its food in rivers consisted of fish, molluscs, insect larvæ, amphipods, shrimps, isopods, and crayfishes, and of fish and crayfish in lakes. Hankinson (1908) found midges in all stages of development, crayfish, insects and larvæ, snails, leeches, and entomostracans. Tracy (1910) reports small fishes, insects, etc. Reighard (1915) found the perch in Douglas Lake eating each other.

All these observations show that the perch is a versatile feeder. At any age it may feed largely on entomostracans, insects, molluscs, or almost anything else that is edible.

Percina caprodes (Rafinesque) var *zebra* Agassiz, log-perch.

Data for 1914 (Pearse, 1915, *Boeleichthys fusiformis*).—Station 24; October 3; number examined, 7. Average length, 65.6. Food: Insect larvæ, 84; adult insects, 6.7; amphipods, 2.4; ostracods, 0.1; copepods, 0.3; cladocerans, +; silt and débris, 6.

Station 23, in rapids; April 28, 1915; number examined, 14. Length: Maximum, 94; minimum, 60; average, 76.3. Food: Fish eggs, 51.6; Chironomus larvæ, 5.3; Hydropsyche alternans larvæ, 10.3; Hyalella, 14.2; Cyclops, 0.2; leech, 1.8; plant remains, 4.8; filamentous algæ, 3.4; silt and débris, 7.8.

Station 24; July 2; number examined, 2. Lengths: 79, 63. Food: Chironomus viridis larvæ, 5; C. lobiferus larvæ, 5; C. tentans larvæ, 7.5; Protenthes culiciformis larvæ, 4; Cricotopus trifasciatus larvæ, 27.5; May-fly nymphs, 3.5; Ecdyurus maculipennis nymphs, 1.5; Callibætis nymphs, 1; Cricotopus trifasciatus pupæ, 15; Chironomus lobiferus pupæ, 10; C. tentans pupæ, 5; leech, 15.

Summary.—Food: Insect larvæ, 55; pupæ, 30; leech, 15.

Station 23, on beach at mouth of river; August 19; number examined, 1. Length: 44. Food: Chironomus viridis larvæ, 25; C. flavicingula larvæ, 15; C. tentans larvæ, 50; C. tentans pupæ, 6; cladocerans, 4.

Station 24; September 17; number examined, 1. Length: 56. Food: Chironomus digitatus larvæ, 95; May-fly nymphs, 5.

Station 23, in rapids by locks; June 20, 1916; number examined, 2. Lengths: 100 and 98. Food: Simulium larvæ, 42.5; diptera pupæ, 25; Hyalella, 32.5.

Grand summary for 1914, 1915, and 1916.—Number examined, 27. Length: Maximum, 100; minimum, 44; average, 72.9. Food: Fish eggs, 27.8; insect larvæ, 45.5; insect pupæ, 3.7; adult insects, 1.7; amphipods, 6.6; Entomostraca, 0.3; leeches, 2; plant remains, 3.4; algæ, 1.7; silt and debris, 5.7.

This summary shows that the log-perch fed mostly on insects and fish eggs. This agrees in part with the results of Forbes and Richardson (1908), who found that two-thirds of the food was insects, but the other third mostly entomostracans. This fish evidently feeds by choice on the aquatic insects and their larvæ found among vegetation.

Pimephales notatus (Rafinesque). Blunt-nosed minnow.

Station 15; November 21, 1914; number examined, 4. Length: Maximum, 32.2; minimum, 23.6; average, 27.7. Food: Cyclops, 22.5; Chydorus sphæricus, 2.5; cladoceran fragments, 62.5; filamentous algæ, 12.5.

Station 19; December 3; number examined, 4. Length: Maximum, 30; minimum, 26.4; average, 28.4. Food: Chironomid larvæ, 25; Cyclops, 10; Chydorus sphæricus, 15; Eurycercus lamellatus, 22.5; cladoceran fragments, 25; diatoms, 2.5.

Summary.—Food: Copepods, 10; cladocerans, 62.5; algæ, 2.5.

Station 23; June 14, 1915; number examined, 1. Length: 70. Food: Chironomus tenellus adults, 95; Cyclops, 5.

Station 27; June 17; number examined, 29. Length: Maximum, 62; minimum, 34; average, 46. Food: Orthocladius sordidellus larvæ, 9; Probezzia pallida larvæ, 2.6; Chironomus lobiferus larvæ, 4; C. l. pupæ, 7.1; adult midges, 6; ostracod, +; Cyclops, 0.2; Chydorus sphæricus, 3; Bosmina longirostris cornuta, 30.7; ephippial eggs, 0.2; Eurycercus lamellatus, 0.5; cladocerans, 0.1; filamentous algæ, 8.2; plant remains, 1.9; fine débris and silt, 24.2.

Summary.—Food: Insect larvæ, 15.6; pupæ, 7.1; adult insects, 6; ostracods, +; copepods, 0.2; cladocerans, 34.5; algæ, 8.6; plants, 1.9; silt and débris, 24.2.

Station 28; June 17; number examined, 10. Length: Maximum, 36.5; minimum, 26.2; average, 30.2. Food: Chironomid larvæ, 19.5; Chironomus lobiferus pupæ, 4.1; mite, 0.1; ostracods, 0.5; Cyclops, 2.1; oligochætes, 6; flagellates, 0.1; diatoms, 0.5; Pediastrum, 0.1; filamentous algæ, 49.8; plant remains, 0.2; silt and débris, 17.

Summary.—Food: Insect larvæ, 19.5; pupæ, 4.1; mite, 0.1; ostracods, 0.5; copepods, 2.1; oligochætes, 6; protozoans, 0.1; algæ, 50.4; plants, 0.2; silt and débris, 17.

Station 3; June 24; number examined, 3. Lengths: 43, 41.7, 32.5. Food: Chironomid larvæ, 1.7; Orthocladius sordidellus pupæ, 1.3; adult midges, 3.3; Chydorus sphæricus, 2.7; oligochætes, 28; Closterium, 0.3; filamentous algæ, 50; plant remains, 0.3; silt and débris, 12.3.

Station 24; July 2; number examined, 2. Lengths: 48.5, 28. Food: Chironomid larvæ, 25; chironomid pupæ, 25; ostracods, 0.5; oligochætes, 49; sand, 0.5.

Station 23; July 3; number examined, 1. Length: 58.5. Food: Chydorus sphæricus, 1; filamentous algæ, 60; silt and débris, 39.

Station 23; July 9; number examined, 4. Length: Maximum, 54.5; minimum, 34; average, 44.6. Food: Chironomid larvæ, 12.5; Chironomus fulviventris larvæ, 0.5; C. tentans larvæ, 0.8; Chydorus sphæricus, 0.1; oligochætes, 39.9; desmids, 1.2; filamentous algæ, 29; silt and débris, 16.

Summary.—Food: Insect larvæ, 13.8; cladocerans, 0.1; oligochætes, 39.9; algæ, 30.2; silt and débris, 16.

Station 5; August 18; number examined, 2. Lengths: 41, 35. Food: Chironomid larvæ, 5; ostracods, 3.5; Cyclops, 2.5; Eurycercus lamellatus, 4; plant remains, 2.5; silt and débris, 82.5

Grand summary.—Number examined, 60. Length: Maximum, 70; minimum, 23.6; average, 40. Food: Insect larvæ, 14.5; pupæ, 5.8; adult insects, 4.5; ostracods, 0.3; copepods, 2.6; cladocerans, 25.1; oligochætes, 7; algæ, 19.3; plant remains, 0.9; silt and débris, 20.

As would be expected from its long intestine, the blunt-nosed minnow eats a good deal of silt, bottom débris, and plants, though entomostracans and insects constitute more than half of its food. Certain individuals had taken foods as follows: Chironomus lobiferus pupæ, 100; Bosmina longirostris cornuta, 100; oligochætes, 98; filamentous algæ, 90; silt and débris, 100. These figures show that the minnow is a versatile feeder. The food in the stomach has always been chewed into fine pieces.

Forbes and Richardson (1908) stated that the stomach of this species is commonly packed with mud containing filamentous algæ and miscellaneous vegetable débris. Hankinson (1908) found the food varies greatly, but consists chiefly of small organisms taken from the bottom, from water plants, and from the water. These fish eat the eggs of the black bass, Johnny darter, miller's thumb, and sunfish. Sometimes they devour the newly hatched fry of their own species. Other foods mentioned consisted of filamentous algæ, desmids, entomostracans, and insects. Reighard (1915) said this minnow is a "mud eater."

Pimephales promelas (Rafinesque.) Black-head minnow, fathead.

Station 17; September 18, 1915; number examined, 3. Lengths: 51, 50.5, 45. Food: Tanytarsus gregarius larvæ, 79.3; mites, 1.6; amphipods, 0.3; Cyclops, 2.6; oligochætes, 6; diatoms and other algæ, 1.3; sand and débris, 8.3.

Pomoxis sparoides (Lacépède). Black crappie, calico bass, silver bass.

Station 17; April 10 and 13, 1915; number examined, 4. Lengths: 145, 130, 132, 75. Food: Minnows, 12.5; chironomid larvæ, 1.2; May-fly nymphs, 22.5; Siphlurus nymphs, 0.7; Enallagma hageni, 12.5; Smithiurus, 0.5; Corixa adults, 24.5; Hyalella, 8.7; Chydorus sphæricus, 0.2; plant remains, 11.5; filamentous algæ, 2.3; fine débris, 1.2.

Summary.—Food: Fish, 12.5; insect larvæ, 36.9; adult insects, 25; amphipods, 8.7; cladocerans, 0.2; plants, 11.5; algæ, 2.3; débris, 1.2.

Station 21, along south shore of Lake Wingra; number examined, 4. Lengths: 154, 140, 70, 55. Food: Fish, 6.2; Chironomus nigricans larvæ, 0.1; Tanypus monilis larvæ, +; Probezzia larvæ, 10; caterpillar, 11; Bætis nymphs, 4.5; Chironomus fulviventris pupæ, 38.5; mites, 1.3; Dikerogammarus fasciatus, 0.5; Hyalella, 10; ostracods, 2.5; Cyclops bicuspidatus, 21.1; Chydorus sphæricus, 1.8; filamentous algæ +.

Summary.—Food: Fish, 6.2; insect larvæ, 24.3; pupæ, 38.5; mites, 1.3; amphipods, 10.5; ostracods, 2.5; copepods, 21.1; cladocerans, 1.8; algæ, +.

Station 17; August 24; number examined, 1. Length: 186. Food: Cænis diminuta nymph, 8; moth, 81; Eurycercus lamellatus, 1; Wolffia, 10.

Station 6; August 25; number examined, 1. Length: 100. Food: Chironomus viridis larvæ, 10; C. lobiferus pupæ, 10; Hyalella, 15; Simocephalus, 61.9; Ceratophyllum, 3; seed, 0.1.

Station 28; September 15; number examined, 3. Lengths: 116, 105, 104. Food: Fish, 79; Chironomus viridis larvæ, 0.3; Cænis diminuta nymph, 1; Corixa adult, 3.3; Cyclops, 0.3; Chydorus, 0.2; Daphnia, 11.7; plant remains, 3.3.

Station 24; September 17; number examined, 1. Length: 45. Food: Insect larvæ, 15; chironomid larvæ, 10; Hyalella, 60; Cyclops, 3; Chydorus sphæricus, 2; Daphnia, 10.

Station 22; October 27; number examined, 36. Length: Maximum, 48; mininum, 36; average, 40.4. Food: Fish, 0.3; insect larvæ, 1; chironomid larvæ, 3.6; Tanypus gregarius larvæ, 9; Bætisca nymph, 4.3; Chironomus lobiferus pupæ, 0.4; Smithiurus, 0.6; moth, 0.4; adult midges, 2.5; Probezzia pallida adults, 5.8; Cordylura adults, 0.6; Hyalella, 3.5; ostracods, 21.7; Diaptomus, 0.2; Canthocamptus, 20.7; Cyclops, 18.6; Chydorus, 1.5; Pleuroxus, 1; Simocephalus, +; seeds, 0.4.

Summary.—Food: Fish, 0.3; insect larvæ, 17.9; pupæ, 0.4; adult insects, 9.9; amphipods, 3.5; ostracods, 21.7; copepods, 29.5; cladocerans, 1.5; plants, 0.4.

Station 26; November 27; number examined, 7. Length: Maximum, 221; minimum, 160; average, 184.1. Food: Insect larvæ, 0.8; Chironomus viridis larvæ, 8.9; C. tentans larvæ, 4.3; Bætisca nymphs, 2.1; Ischnura verticalis nymphs, 2.1; Canthocamptus, +; Daphnia, 54.7; Leptodora, 27.1.

Summary.—Food: Insect larvæ, 18.2; copepods, +; cladocerans, 81.8.

Station 18; April 29, 1916; number examined, 3. Length: Maximum, 188; minimum, 159; average, 172.3. Food: Minnow, 13.3; Chironomus fulviventris larvæ, 3.3; C. lobiferus larvæ, 3.3; Ephemerella sp. nymphs, 1.6; Celithemis eponina nymph, 6.6; Setodis grandis larvæ, 0.3; Corixa adult, 1.6; Hyalella, 69; filamentous algæ, 0.3; leaf 0.1; plant remains, 0.1.

Summary.—Food: Fish, 13.3; insect larvæ, 15.1; insect adults, 1.6; amphipods, 69; plants, 0.5.

Station 18; May 13; number examined, 1. Length: 200. Food: Chironomus fulviventris larvæ, 5; Notonecta nymphs, 1; Chironomus decorus pupæ, 1; Corixa adults, 3; adult beetles, 28; Hyalella, 50; Eurycercus, 2; filamentous algæ, 10.

Summary.—Food: Insect larvæ, 6; insect pupæ, 1; insect adults, 31; emphipods, 50; Entomostraca, 2; plants, 10.

Station 28; May 30; number examined, 2. Length: Maximum, 183; minimum, 170; average, 176.5. Food: Fish eggs, 1; Chironomus fulviventris larvæ, 12.5; C. lobiferus larvæ, 16.5; C. decorus larvæ, 2.5; Probezzia glaber larvæ, 5; Notonecta nymphs, 2.5; Chironomus sp. pupæ, 35; C. fulviventris pupæ, 5; C. decorus pupæ, 5; mites, 10; Hyalella, 10.

Summary.—Food: Fish eggs, 1; insect larvæ, 39; insect pupæ, 45; mites, 10; amphipods, 10.

Station 26; July 13; number examined, 3. Length: Maximum, 183; minimum, 142; average, 169.3. Food: Minnow, 3.5; Chironomus lobiferus larvæ, 25; Enallagma hageni nymphs, 3.3; Chironomus sp. pupæ, 12.6; Corixa adults, 0.3; Hyalella, 0.3; Daphnia, 6.3; D. pulex, 16.6.

Summary.—Food: Fish, 3.5; insect larvæ, 28.3; insect pupæ, 12.6; insect adults, 0.3; amphipods, 0.3; cladocera, 22.9.

Grand summary for 1915 and 1916.—Number examined, 66. Length: Maximum, 221; minimum, 35; average, 90.5. Food: Fish eggs, 0.1; fish, 7.1; insect larvæ, 19.1; insect pupæ, 4.6; adult insects, 8.8; mites, 0.4; amphipods, 10.6; Entomostraca, 47.4; plants, 1.5; silt and débris, +.

The black crappie depends on entomostracans (47.4 per cent), insects (33.5 per cent), amphipods, and small fish for its food. Its form fits it to live among aquatic plants, and in general its food comes from such situations. The largest fish examined (November 27, 1915), however, had eaten over three-fourths pelagic entomostracans. Forbes and Richardson (1908) stated that the crappies are strictly carnivorous, living mainly on insects, crustaceans, and fish.

Roccus chrysops (Rafinesque). White bass.

Station 15; June 6, 1915; number examined, 1. Length: 165. Food: Chironomus decorous larvæ, 40; Protenthes choreus larvæ, 39.9; Corethra larvæ, 10; Hyalella, 0.1.

Summary.—Food: Chironomid larvæ, 99.9; amphipods, 0.1.

Station 5; August 18; number examined, 1. Length: 29. Food: Cyclops, 65; Bosmina longirostris cornuta, 35.

Station 5; August 25; number examined, 1. Length: 35. Food: Corixa adults, 100.

Station 5; August 25; number examined, 2. Lengths: 35, 29. Food: Chironomus adults, 5; Cyclops, 60; Bosmina longirostris cornuta, 30; Simocephalus, 5.

Summary.—Food: Adult insects, 5; copepods, 60; cladocerans, 35.

Station 5; August 30; number examined, 6. Length: Maximum, 44; minimum, 32; average, 37.9. Food: Insect eggs, 20; chironomid larvæ, 0.8; Chironomus decorus larvæ, 1.6; Bætisca nymphs, 13.1; Enallagma hageni nymphs, 6.6; Chironomus lobiferus pupæ, 10; C. viridis pupæ, 1.6; Hyalella, 9.1; Cyclops, 27; Cyclops serrulatus, 6.6; chydorids, 1.8; Simocephalus, 1.

Summary.—Food: Insect larvæ, 42.1; pupæ, 11.6; amphipods, 9.1; copepods, 33.6; cladocerans, 2.8.

Station 5; September 2; number examined, 1. Length: 33. Food: Chironomus decorus larvæ, 5; Protenthes culiciformis pupæ, 5; Hyalella, 15; ostracods, 5, Cyclops, 65; cladocerans, 5.

Station 5; September 22; number examined, 1. Length: 220. Food: Fundulus diaphanus menona, 55; Chironomus decorus larvæ, 8; Corethra larvæ, 20; Chironomus decorus pupæ, 8; C. d. adult, 7; Leptocerus dilutus adult, 2.

Summary.—Food: Fish, 55; insect larvæ, 28; pupæ, 8; adult insects, 9.

Station 15; depth, 13 meters; November 13; number examined, 1. Length: 145. Food: Daphnia, 60; Leptodora, 40.

Grand summary.—Number examined, 14. Length: Maximum, 220; minimum, 29; average, 65.6. Food: Fish, 4.2; insect eggs, 8.6; larvæ, 22.2; pupæ, 5.8; adult insects, 8.4; amphipods, 5; ostracods, 0.4; copepods, 29.6; cladocerans, 16.3.

The white bass feeds primarily on entomostracans (46.3 per cent) and insects (45 per cent). The adults eat insects more than anything else, but also take fish. Forbes and Richardson (1908) mentioned insects, crustaceans, and fishes as constituents of the food of this species. Two adults examined by the writer in 1914 were filled with adult midges.

Salmo irideus (Jordan and Evermann). Rainbow trout.

Station 30; August 26, 1915; number examined, 1. Length: 126.5. Food: Chironomus fulviventris larvæ, 5; Tanypus decoloratus larvæ, 5; Psychoda larvæ, 5; Phryganea larvæ, 8; Odontomyia larvæ, 10; Chironomus fulviventris pupæ, 1; C. lobiferus pupæ, 2; leptid adult, 4; Peltodytes 12-punctipennis adult, 3; Julus, 10; Gammarus limnæus, 42; Physa, 5.

Summary.—Food: Insect larvæ, 33; pupæ, 3; adult insects, 7; millipeds, 10; amphipods, 42; snails, 5.

Salvelinus fontinalis (Mitchill.) Brook trout.

Station 30; August 26, 1915; number examined, 18. Length: Maximum, 160; minimum, 87; average, 103.2. Food: Dipterous larvæ, 3.5; Chironomus fulviventris larvæ, 13.2; Tanypus decoloratus larvæ, 1; Psychoda larvæ, 0.3; Phryganea larvæ, 11.5; Agabus larvæ, 1.8; Odontomyia larvæ, 1.1; Dytiscus hybridus larvæ, 0.5; Dixa larvæ, 1; Chironomus fulviventris pupæ, 18.2; C. lobiferus pupæ, 0.2; leptid flies, 0.8; Peltodytes 12-punctipennis adult, 0.2; Agabus adult, 1.1; Corixa adults, 0.3; Camponotus adult, 0.1; Melanoplus femurrubrum adult, 3; jassid bug, 0.1; Julus, 0.4; Limnesia histrionica, 0.4; Gammarus limnæus, 35.5; Asellus communis, 0.5; Procellio rathkei, 0.8; Physa, 1.4; seeds, +; Polygonium seeds, 0.1.

Summary.—Food: Insect larvæ, 33.9; pupæ, 18.4; adult insects, 5.6; millipeds, 0.4; mites, 0.4; amphipods, 35.5; aquatic isopods, 0.5; terrestrial isopods, 0.8; snails, 1.4; plant seeds, 0.1.

This trout feeds largely on insects and other arthropods. The Fish Manual (1900) has this statement: "The brook trout has a voracious appetite and takes advantage of every opportunity to satisfy it, except in the spawning season, when it takes no food at all. It is strictly a carnivorous fish, its food consisting chiefly of crustacea, mollusca, and various forms of insects and worms. When pressed with hunger, it does not hesitate to devour its own kind." Tracy (1910) said this fish will eat nearly any small living creature—insects, fish, its own eggs and young, tadpoles, newts, etc.

Schilbeodes gyrinus. (Mitchill.) Tadpole cat.

Data for 1914 (Pearse, 1915).—Station 4; August 6; number examined, 5. Length: Maximum, 26.8; minimum, 17.6; average, 22.3. Food: Insect larvæ, 8; adult insects, 4; Hyalella, 0.4; ostracods, 0.4; copepods, 62; cladocerans, 1.6; algæ, 4.2; silt and débris, 15.

Station 5; May 12; number examined, 14. Length: Maximum, 76; minimum, 30.3; average, 42.8. Food: Insect larvæ, 1.4; chironomid larvæ, 2; Chironomus lobiferus larvæ, 7; C. fulviventris larvæ, 1.8; Pelopia monilis larvæ, 3; Orthocladius soldidellus larvæ, 2; May-fly nymphs, 12; Bætis pygmæa nymphs, 10; Callibætis nymphs, 10; Corixa nymphs, 1.3; Neuronia postica pupæ, 2.4; Chironomus lobiferus pupæ, 2; grasshopper, 1.4; Enallagma antennatum adults, 5; adult dipteron, 2; Hyallella, 7; ostracods, 6.5; Cyclops, 2; chydorus sphæricus, 11; Simocephalus, 0.5; Eurycercus lamellatus, 6.3; oligochætes, 1.4; fine débris, 2.

Summary.—Food: Insect nymphs and larvæ, 50.5; pupæ, 4.4; adult insects, 8.4; amphipods, 7; ostracods, 6.5; copepods, 2; cladocerans, 17.8; oligochætes, 1.4; débris, 2.

Station 5; June 1; number examined, 9. Length: Maximum, 45; minimum, 38.5; average, 42.6. Food: Chironomus lobiferus larvæ, 4; Orthocladius sordidellus larvæ, 16; damsel-fly nymphs, 1.1; beetle larvæ, 33.2; Naucoris nymphs, 8.3; Chironomus lobiferus pupæ, 2.7; C. decorus pupæ, 7.2; Odontomyia pupæ, 0.5; Lachnosterna adult, 1.9; ostracods, 8.5; Cyclops, 9; oligochætes, 5.5; filamentous algæ, 0.1; fine débris, 2.

Summary.—Food: Insect larvæ, 62.6; pupæ, 10.4; adult insects, 1.9; ostracods, 8.5; copepods, 9; oligochætes, 5.5; filamentous algæ, 0.1; fine débris, 2.

Station 5; August 9; number examined, 2. Lengths: 21.5, 21. Food: Protenthes culiciformis larvæ, 15; Callibætis nymphs, 17.5; mite, 1; Hyalella, 12.5; ostracods, 1; Chydorus sphæricus, 0.5; Camptocercus, 17.5; oligochætes, 12.5; seeds, 17.5; fine débris, 5.

Summary.—Food: Insect larvæ, 32.5; mites, 1; amphipods, 12.5; ostracods, 1; cladocerans, 18; oligochætes, 12.5; seeds, 17.5; débris, 5.

Near Station 5, on lake shore; August 18; number examined, 14. Length: Maximum, 63; minimum, 14; average, 25.8. Food: Chironomus lobiferus larvæ, 1.4; damsel-fly nymphs, 1.4; May-fly nymphs 0.7; Ecdyurus maculipennis nymphs, 1.3; Cænis diminuta nymphs, 27.7; Hyalella, 6.7; ostracods, 1, Camptocercus, 0.2; cladocerans, 0.2; Planorbis, 0.3; oligochætes, 42.7; seeds, 15; duckweed, 1.4.

Summary.—Food: Insect larvæ, 32.5; amphipods, 6.7; ostracods, 1; cladocerans, 0.4; snails, 0.3; oligochætes, 42.7; plants, 16.4.

Station 5; August 18; number examined, 10. Length: Maximum, 27.8; minimum, 18; average, 22.3. Food: Chironomus fulviventris larvæ, 3; C. digitatus larvæ, 1.5; Tanypus decoloratus larvæ; 2.5; Orthocladius sordidellus larvæ, 2.5; May-fly nymphs, 3.5; Bætisca nymphs, 1.5; Cænis diminuta nymphs, 10.5; Enallagma antennatum adult, 3.5; Hyalella, 27.3; ostracods, 3; Cyclops, 2; Chydorus, phæricus, 0.5; Simocephalus, 0.7; Camptocercus, 2.3; oligochætes, 31.4; seeds, 1; Myriophyllum, 3; sand, 0.3.

Summary.—Food: Immature insects, 25; adult insects, 3.5; amphipods, 27.3; ostracods, 3; copepods, 2; cladocerans, 3.5; oligochætes, 31.4; plants, 4; sand, 0.3.

Station 5; September 15; number examined, 1. Length: 59. Food: Insect larvæ, 7; Hyalella, 55; ostracods, 8; cladocerans, 15; fine débris, 15.

Grand summary for 1914 and 1915.—Number examined, 55. Length: Maximum, 76; minimum, 14; average, 34.3 Food: Insect larvæ, 36; pupæ, 4.4; adult insects, 3.6; mites, +; amphipods, 10.3; ostracods, 4; copepods, 7.9; cladocerans, 6.1; snails, 0.1; oligochætes, 18.3; plants, 5.9; algæ, 0.1; silt and débris, 3.

The tadpole cat feeds chiefly on insects (44 per cent), oligochætes (18.3 per cent), and small crustaceans (28.3 per cent). The items in its diet show that it gets its food on the bottom and among aquatic plants. The smaller individuals apparenly depend upon crustaceans and oligochætes, larger fishes turn more to insects. Forbes and Richardson (1908) found this species feeding on amphipods isopods, entomostracans, insect larvæ, and small fish. Hankinson (1908) found insect fragments.

Stizostedion vitreum (Mitchill). Wall-eyed pike, pike perch, jack-salmon.

Station 28; September 15, 1915; number examined, 2. Lengths: 448, 425. Food: Fish, 100.

Station 29; November 14; number examined, 9. Length: Maximum, 520; minimum, 375; average, 441. Food: Rana pipiens, 11.1; fishes (one a sunfish), 88.9.

Grand summary.—Number examined, 11. Average length: 440. Food: Frogs, 9.1; fishes, 90.9.

Forbes and Richardson (1908) stated that this species feeds chiefly on fish, sometimes varying its diet with crayfishes.

Umbra limi (Kirtland). Mud minnow, mudfish.

Data for 1914 (Pearse, 1915).—Number examined, 60. Average length: 33.5. Food: Insect larvæ, 21; adult insects, 16.3; mites, 0.3; amphipods, +; ostracods, 33.9; copepods, 0.5; cladocerans, 1.2: snails, 0.7; Sphæridæ, 0.2; oligochætes, 1; nematodes, 0.7; protozoans, 0.1; plant remains, 1.9; algæ, 15.1.

Station 21; April 28, 1915; number examined, 9. Length: Maximum, 80; minimum, 31; average, 51.1. Food: Insect larvæ, 3; Platyphylax designatus larvæ, 4.5; Chironomus viridis larvæ, 1; Tanypus decoloratus larvæ, 3.3; Pelopia flavifrons larvæ, 3.3; Odontomyia larvæ, 4.5; Haliplus adult, 0.2; Corixa adult, 4; mites, 2; Hyalella, 12; Dikerogammarus fasciatus, 26; Cyclops, 0.3; C. viridis, 5.8; C. fimbriatus, 5; cladocerans, 0.3; Chydorus sphæricus, 0.5; leech, 5.5; oligochætes, 12; plant remains, 1.5; Pleurococcus, 2.5; diatoms, 0.5; silt, 1; fine débris, 1.

Summary.—Food: Insect larvæ, 19.6; adult insects, 4.2; mites, 2; amphipods, 38; copepods, 11.1; cladocerans, 0.8; leech, 5.5; oligochætes, 12; plants, 1.5; algæ, 3; silt and débris, 2.

Station 16; May 15; number examined, 1. Length: 68.7. Food: Adult midges, 10; earthworm, 79; diatoms, 1; silt and débris, 10.

Station 5; June 1; number examined, 4. Lengths: 68, 60, 54, 49.5. Food: Insect larvæ, 11; chironomid larvæ, 0.5; Chironomus lobiferus larvæ, 2.2; Orthocladius sordidellus larvæ, 20.4, chironomid pupæ, 9.6; Probezzia pupæ, 0.6; adult weevil, 1; adult midges, 6.2; ostracods, 4; Dikerogammarus, 1.2; Cyclops, 1; Chydorus, 0.2; Eurycercus lamellatus, 1.2; Physa, 1.7; seeds, 14; Wolffia, 2.5; plants, 0.2; filamentous algæ, 0.3; Pleurococcus, 20; silt and débris, 2.5.

Summary.—Food: Insect larvæ, 34.1; pupæ, 10.2; adult insects, 7.2; ostracods, 4; amphipods, 1.2; copepods, 1; cladocerans, 1.4; snails, 1.7; plants, 16.7; algæ, 20.3; silt and débris, 2.5.

Station 21; June 12; number examined, 10. Length: Maximum, 179; minimum, 35; average, 63.9. Food: Insect larvæ, 1.5; chironomid larvæ, 0.7; Chironomus larvæ, 1; Chironomus fulviventris larvæ, 25; Palpomyia longipennis larvæ, 3; Cricotopus trifasciatus larvæ, 2.5; C. t. pupæ, 8.7; chironomid pupæ, 4.3; adult midges, 11; mites, 0.3; ostracods, 0.1; Dikerogammarus, 26.9; Cyclops, 2.7; Physa, 0.8; Pleurococcus, 3.5; silt and débris, 7.

Summary.—Food: Insect larvæ, 33.7; pupæ, 12.1; adult insects, 11; mites, 0.3; ostracods, 0.1; amphipods, 26.9; copepods, 2.7; snails, 0.8; algæ, 3.5; silt and débris, 7.

Station 25; June 17; number examined, 10. Length: Maximum, 84; minimum, 42.5; average, 49.3. Food: Chironomid larvæ, 2; Libellula luctuosa nymphs, 10; chironomid pupæ, 2.5; Haliplus adults, 2.5; Corixa adults, 5; mites, 3; ostracods, 32.2; Cyclops, 7; Chydorus, 1.5; Simocephalus, 4.6; Planorbis, 5.5; Limnæa, 3.5; oligochætes, 6; filamentous algæ, 1.2; Pleurococcus, 9; silt and débris, 4.5.

Summary.—Food: Insect larvæ, 12; pupæ, 2.5; adult insects, 7.5; mites, 3; ostracods, 32.2; copepods, 7; cladocerans, 6.1; snails, 9; oligochætes, 6; algæ, 10.2; silt and débris, 4.5.

Station 28; July 2; number examined, 1. Length: 47.5. Food: Oxyethira larvæ, 10; carabid-beetle larvæ, 10; Odontomyia vertebrata larvæ, 10; ostracods, 5; Hyalella, 60; Cyclops, 5.

Summary.—Food: Insect larvæ, 30; ostracods, 5; amphipods, 60; copepods, 5.

Station 25, in ditch along road; number examined, 14. Length: Maximum, 25.2; minimum, 15.1; average, 20.6. Food: Insect larvæ, 0.3; chironomid larvæ, 5; Chironomid tentans larvæ, 5.3; Palpomyia longipennis larvæ, 0.3; Cricotopus trifasciatus larvæ, 7; Cænis diminuta nymphs, 0.7; beetle larvæ, 3.5; dascyllid larvæ, 8.5; midge pupæ, 3.5; adult bug, 1.8; insect remains, 0.3; adult midges, 4.6; Naucoris adult, 4.4; Collembola, 0.8; mites, 0.3; Hermannia bistriata, 5.6; ostracods, 12.2; Cyclops, 11; Canthocamptus, 1; chydorid, 0.1; Planorbis, 2; Limnæa, 5.2; oligochætes, 7; rotifers, 1.3; Oscillaria, 0.7; Volvox and other algæ, 0.3; filamentous algæ, 0.1; Pleurococcus, 4.3; sand, 1.4.

Summary.—Food: Insect larvæ, 30.6; pupæ, 3.5; adult insects, 11.9; mites, 5.9; ostracods, 12.2; copepods, 12; cladocerans, 0.1; snails, 7.2; oligochætes, 7; rotifers, 1.3; algæ, 54; sand, 1.4.

Station 23; August 14; number examined, 1. Length: 51. Food: Hyalella, 25; Cyclops, 1; Chydorus, 1; plant remains, 73.

Grand summary for 1914 and 1915.—Number examined, 110. Length: Maximum, 179; minimum, 15.1; average, 41.9. Food: Insect larvæ, 21.9; pupæ, 2.1; adult insects, 10.9; spiders, 0.1; mites, 1.2; amphipods, 6.5; ostracods, 23.1; copepods, 3.6; cladocerans, 1.3; snails, 2.3; Sphæridæ, 0.1; oligochætes, 2.9; leeches, 1.1; nematodes, 0.4; rotifers, 2; protozoans, 0.2; plants, 2.5; algæ, 11.1; silt and débris, 1.4; unidentified, 3.8.

The mud minnow is a rather versatile feeder, with the chief constituents of its food, insects (35 per cent), entomostracans (31.3 per cent), and vegetation (13.6 per cent). Forbes and Richardson (1908) found that Wolffia and unicellular algæ formed three-fourths of the food of this species, insects and crustaceans making up the rest. Hankinson (1908) reported entomostracans, algæ, mites, midge larvæ, snails, and insects.

III. FOODS UTILIZED BY FISHES.

DIFFERENT SPECIES OF FISHES HAVE DIFFERENT FOOD HABITS.

Table 1 shows the different kinds of food eaten by the shore fishes of lakes. If more complete information is desired it may be obtained from the preceding section, where the food of the fishes in each catch is given in considerable detail.

Most fishes are not indiscriminate feeders, but select specific things from the available food supply. A good illustration of this point is furnished by the fishes caught together at station 18, July 3, 1915. The foods taken by each of these fish are shown in Table 3, and it will be noted that the different species were about the same average size. The black bass is the most versatile, having taken 21 different items of food, the bluegill comes next with 16, the shiner has 14, and the top minnow 11. Each fish has taken a different item in the largest quantity—i. e., the black bass, 25 per cent *Enallagma antennatum* nymphs; the top minnow, 49 per cent Hyalella; the bluegill, 47 per cent Eurycercus; and the shiner, 42.6 per cent *Daphnia longispina hyalina*. All the fishes had eaten Eurycercus, which must have been abundant, and two had taken Hyalella. The other two items taken in largest amount (*Daphnia hyalina* and *Enallagma antennatum*) were each eaten by only a single species. In Table 4 (which resembles Table 3) three of the species have eaten more fish than any other kind of food, but the fourth has taken none. Table 2 shows the Johnny darter feeding largely on chironomid larvæ and oligochætes; the bream and white bass on Cyclops and other entomostracans; the perch and black bass on the larger insect larvæ, adult insects, and amphipods; the blunt-nosed minnow on mud; the tadpole cat on oligochætes.

An examination has been made of Tables 2, 3, and 4 and ten others similar to them. Each of these tables concerned four or more species of fishes captured at the same time and place. The following 22 species (506 individuals) appear one or more times in them: *Abramis crysoleucas*, *Ambloplites rupestris*, *Amiatus calva*, *Ameiurus melas*, *Ameiurus nebulosus*, *Boleosoma nigrum*, *Catostomus commersonii*, *Cyprinus carpio*, *Esox lucius*, *Etheostoma iowæ*, *Fundulus diaphanus menona*, *Labidesthes sicculus*, *Lepomis incisor*, *Micropterus salmoides*, *Notropis heterodon*, *Perca flavescens*, *Percina caprodes*, *Pimephales notatus*, *Pomoxis sparoides*, *Roccus chrysops*, *Schilbeodes gyrinus*, and *Umbra limi*. The different figures in the bottom line of all tables were added to ascertain whether specific foods were likely to be eaten by one or more fish. The results were as follows: Items appearing once in any one table, 356; twice, 93; thrice, 45; four or more times, 11. This shows that, though fishes may feed on the available foods, different species captured at the same time and place have not eaten the same things.

All things, then, indicate that fishes select food from their environment. In some cases the powers of selecting and rejecting are remarkable. A perch may have its whole alimentary canal packed full of *Daphnias*, when the surrounding water contains *Daphnias* mixed with greater quantities of algæ. Only the animal plankton is taken. The young sucker is able to take such minute living objects as *Difflugia*, *Arcella*, and rotifers from a muddy bottom, rejecting fine particles of silt.

CLASSES OF FOODS UTILIZED BY FISHES.

The foods found in fishes occurring along the shores of Wisconsin lakes fall into nine classes. In order of their importance these rank as follows: (1) Insect larvæ, oligochætes and leeches, 28.7 per cent; (2) entomostracans, 19.1 per cent; (3) fishes and frogs, 13.8 per cent; (4) insect pupæ and adults, 11.7 per cent; (5) amphipods, isopods, and mites, 12.7 per cent; (6) plants, including algæ, 4.2 per cent; (7) mud, silt, and fine débris, 2.6 per cent; (8) molluscs, 2 per cent; and (9) crayfishes, 1.1 per cent. The percentages were obtained from the last line of Table 1.

In the following paragraphs fishes are arranged under each class in the order of their importance. Every species taking food in a particular class is not always recorded but they all appear in Table 1. It must be remembered that there is a preponderance of young fishes in the data from which these results are figured. An examination of more adults would doubtless increase classes 3, 6, 8, and 9.

1. *Fishes feeding upon insect larvæ, oligochætes, and leeches.*—*Boleosoma nigrum*, 77.6 per cent; *Ameiurus melas*, 59.6 per cent; *Schilbeodes gyrinus*, 57.9 per cent; *Persina caprodes*, 54 per cent; *Catostomus commersonii*, 51.5 per cent; *Etheostoma flabellare*, 50.5 per cent; *Ambloplites rupestris*, 46 per cent; *Cyprinus carpio*, 42.5 per cent; *Etheostoma iowæ*, 38.6 per cent; *Micropterus dolomieu*, 37.7 per cent; *Lepomis incisor*, 35.7 per cent; *Cottus ictalops*, 35.3 per cent; *Perca flavescens*, 35.1 per cent; *Roccus chrysops*, 30.8 per cent; *Ameiurus nebulosus*, 30.2 per cent; *Fundulus diaphanus menona*, 26.4 per cent; *Umbra limi*, 25.9 per cent; *Eucalia inconstans*, 24.1 per cent; *Micropterus salmoides*, 23.7 per cent; *Pimephales notatus*, 21.5 per cent; *Pomoxis sparoides*, 18.4 per cent; *Eupomotis gibbosus*, 16.2 per cent; *Notropis heterodon*, 15 per cent.

2. *Fishes feeding upon entomostracans.—Abramis crysoleucas*, 76 per cent; *Pomoxis sparoides*, 53.7 per cent; *Notropis heterodon*, 44.9 per cent; *Ameiurus nebulosus*, 42.1 per cent; *Lebidesthes sicculus*, 40.1 per cent; *Eucalia inconstans*, 38.5 per cent; *Fundulus diaphanus menona*, 36 per cent; *Umbra limi*, 31.3 per cent; *Pimephales notatus*, 28 per cent; *Lepomis incisor*, 24.9 per cent; *Micropterus salmoides*, 18.1 per cent; *Schilbeodes gyrinus*, 18 per cent; *Perca flavescens*, 16.9 per cent.

3. *Fishes feeding upon fishes and frogs.—Stizostedion vitreum*, 100 per cent; *Amiatus calva*, 90.1 per cent; *Lepisosteus osseus*, 88.8 per cent; *Esox lucius*, 84 per cent; *Percina caprodes*, (eggs) 27.8 per cent; *Micropterus dolomieu*, 14.7 per cent; *Eupomotis gibbosus*, (eggs) 9.4 per cent; *Micropterus salmoides*, 8.2 per cent; *Pomoxis sparoides*, 5.7 per cent; *Perca flavescens*, 3.5 per cent; *Roccus chrysops*, 4.2 per cent; *Ambloplites rupestris*, 2 per cent.

4. *Fishes feeding upon insect pupæ and adult insects.—Labidesthes sicculus*, 44.6 per cent; *Micropterus dolomieu*, 39.7 per cent; *Micropterus salmoides*, 31.2 per cent; *Ambloplites rupestris*, 23.3 per cent; *Eucalia inconstans*, 18.1 per cent; *Roccus chrysops*, 14.2 per cent; *Notropis heterodon*, 14.1 per cent; *Umbra limi*, 13 per cent; *Pomoxis sparoides*, 12.7 per cent; *Eupomotis gibbosus*, 10.3 per cent; *Pimephales notatus*, 10.3 per cent; *Ameiurus melas*, 9.9 per cent; *Cyprinus carpio*, 9.6 per cent; *Lepomis incisor*, 9.2 per cent; *Schilbeodes gyrinus*, 9 per cent; *Ameiurus nebulosus*, 6.5 per cent; *Fundulus diaphanus menona*, 4.8 per cent; *Percina caprodes*, 3.9 per cent; *Perca flavescens*, 3 per cent.

5. *Fishes feeding upon amphipods, isopods, and mites.—Cottus ictalops*, 59.1 per cent; *Etheostoma iowæ*, 58 per cent; *Etheostoma flabellare*, 48 per cent; *Perca flavescens*, 24.6 per cent; *Lepomis incisor*, 15.1 per cent; *Fundulus diaphanus menona*, 14.1 per cent; *Micropterus salmoides*, 13.9 per cent; *Ameiurus nebulosus*, 11.8 per cent; *Schilbeodes gyrinus*, 10.3 per cent; *Eupomotis gibbosus*, 9 per cent; *Cyprinus carpio*, 8.7 per cent; *Umbra limi*, 7.8 per cent; *Pomoxis sparoides*, 7.5 per cent; *Eucalia inconstans*, 5.2 per cent; *Boleosoma nigrum*, 5.1 per cent; *Roccus chrysops*, 5 per cent; *Percina caprodes*, 4.6 per cent; *Esox lucius*, 2.5 per cent.

6. *Fishes feeding upon plants, including algæ.—Eupomotis gibbosus*, 25.5 per cent; *Pimephales notatus*, 20.2 per cent; *Notropis heterodon*, 15.6 per cent; *Umbra limi*, 13.6 per cent; *Ameiurus melas*, 7.3 per cent; *Fundulus diaphanus menona*, 6.4 per cent; *Schilbeodes gyrinus*, 6 per cent; *Lepomis incisor*, 5.2 per cent; *Abramis crysoleucas*, 4.5 per cent; *Eucalia inconstans*, 4.4 per cent; *Labidesthes sicculus*, 4 per cent; *Ambloplites rupestris*, 3.3 per cent.

7. *Fishes feeding upon mud, silt, and fine débris.—Pimephales notatus*, 20 per cent; *Notropis heterodon*, 6.5 per cent; *Ameriurus melas*, 6.3 per cent; *Percina caprodes*, 5.7 per cent; *Fundulus diaphanus menona*, 4.2 per cent; *Eucalia inconstans*, 3.7 per cent; *Catostomus commersonii*, 3.6 per cent; *Boleosoma nigrum*, 3.1 per cent; *Schilbeodes gyrinus*, 3 per cent.

8. *Fishes feeding upon molluscs.—Eupomotis gibbosus*, 25.8 per cent; *Cyprinus carpio*, 6.9 per cent; *Lepomis incisor*, 4.5 per cent; *Fundulus diaphanus menona*, 3.9 per cent; *Ameiurus melas*, 3.7 per cent; *Perca flavescens*, 3.7 per cent; *Eucalia inconstans*, 3.7 per cent; *Etheostoma iowæ*, 3 per cent; *Umbra limi*, 2.4 per cent.

9. *Fishes feeding upon crayfish.—Amploplites rupestris*, 16.1 per cent; *Amiatus calva*, 9.4 per cent; *Ameiurus melas*, 6.1 per cent; *Micropterus salmoides*, 2.6 per cent.

IV. ADAPTABILITY OF FOOD HABITS.

ALTERNATIVE FOODS.

Fish prefer certain foods and select from their environment. If the largest single items are picked out from the dietaries of the fishes shown in Table 1, the following results are obtained: Nine species eat more dipterous larvæ than any other single kind of food; six, amphipods; five, cladocerans; four, fishes; two, adult hemipterous insects (*Corixa*); two, *Cyclops;* and one species takes its chief food from gastropods, dipterous pupæ, May-fly nymphs, and ostracods. The next question to be answered is: What will the different fishes eat if their favorite food is not available?

To answer this, the three foods taken in largest quantity (i. e., first, second, and third choice) were selected for each of the 32 species shown in Table 1. For example, the golden shiner, *Abramis crysoleucas*, ate 57.6 per cent cladocerans, 16.5 per cent copepods, 5.7 per cent dipterous pupæ, and other foods. This species was, therefore, put in a class "Cladocera—copepods—dipterous pupæ." The classes and the number of species of fish taking the same three chief items of food were as follows:

Diptera larvæ—Copepoda—Cladocera	3
Cladocera—Diptera larvæ—Amphipoda	3
Diptera larvæ—Ostacoda—Copepoda	2
Cladocera—adult Diptera—Diptera pupæ	1
Cladocera—Copepoda—Diptera pupæ	1
Cladocera—Diptera larvæ—algæ	1
Diptera larvæ—crayfishes—Odonata nymphs	1
Diptera larvæ—Ostracoda—Cladocera	1
Diptera larvæ—Oligochæta—plant remains	1
Diptera larvæ—fish eggs—Trichoptera larvæ	1
Diptera larvæ—Oligochæta—Copepoda	1
Fish—crayfish	1
Fish—adult Diptera—Diptera larvæ	1
Fish—frogs	1
Amphipoda—Ephemerida nymphs—Diptera larvæ	1
Fish—Amphipoda—Hemiptera nymphs or Sphæridæ	1
Amphipoda—Diptera larvæ—Millipeds	1
Amphipoda—Diptera larvæ—Trichoptera larvæ	1
Amphipoda—Diptera larvæ—Diptera pupæ	1
Amphipoda—Diptera larvæ—Coleoptera larvæ	1
Gastropoda—plant remains—toad eggs	1
Adult Hemiptera—Ephemerida nymphs—Diptera larvæ	1
Adult Hemiptera—Ephemerida nymphs—Cladocera	1
Diptera pupæ—silt and débris—Copepoda	1
Cladocera—silt and débris—algæ	1
Ephemerida nymphs—Oligochæta—Amphipoda	1
Ostracoda—Diptera larvæ—Amphipoda	1

Thirty-two species of fishes thus show 27 classes. If only the two chief food items are considered, the number of classes is reduced to 19, as follows:

Amphipoda—Diptera larvæ	4
Diptera larvæ—Copepoda	4
Diptera larvæ—Ostracoda	3
Cladocera—Diptera larvæ	3
Diptera larvæ—Oligochæta	2

Adult Hemiptera—Ephemerida nymphs	2
Cladocera—Copepoda	1
Cladocera—Adult Diptera	1
Cladocera—silt and débris	1
Diptera larvæ—crayfishes	1
Diptera larvæ—fish eggs	1
Fish—Odonata nymphs	1
Fish—frogs	1
Fish—Ephemerida nymphs	1
Amphipoda—Ephemerida nymphs	1
Amphipoda—Cladocera	1
Gastropoda—plant remains	1
Diptera pupæ—silt and débris	1
Ephemerida nymphs—Oligochæta	1

Both these comparisons give further support to the statements made under section III, showing that different kinds of fishes have specific preferences for certain foods. Nine species make their chief food the larvæ of dipterous insects, which are far more abundant than anything else. When these eat something different from their favorite food, they do not all take the same kind of food but select five to seven new things. It is difficult to group fishes into large classes on the basis of similarity in food. Essentially the same conclusions were reached by Forbes[a] from a study of 1,221 Illinois fishes.

VARIATION IN FOOD OF FISHES COLLECTED IN DIFFERENT LOCALITIES AND AT DIFFERENT TIMES.

In order to ascertain how much each species of fish varied in the selection of its principal food at different times and in different places, a study of the data for 1915 presented in section II was made. The chief foods taken at the different stations were summarized as far as possible. If a species took a different kind of food each time it was collected, it will of course be rated as one of versatile food habits; if its chief food was the same in all collections, it is considered as having a limited range of diet. The results of the comparison are shown in Table 5.

It will be noted that some species, like the rock bass, bluegill, and black bullhead, are rather versatile feeders; others (Johnny darter, miller's thumb, pickerel, gar) stick to one food. All the species taken together show a change in the chief food with time and place in about half the collections. These estimates, however, do not consider the diversity in size among the fishes examined.

VARIATION OF FOOD AT DIFFERENT PERIODS OF THE LIFE CYCLE.

The data collected for this paper are not complete enough to make very satisfactory comparisons possible between young and adult fish of each species. Of the 32 species studied, in only 20 were enough individuals of different sizes collected so that comparisons can be made.

Eight species feed more on amphipods, insect larvæ, and adult insects and less on entomostracans as they increase in size. Six change from insect larvæ to fishes or crayfishes. Each of the following changes is characteristic of a single species of fishes: Snails and amphipods to plants; oligochætes to molluscs; Hyalella to fish; insect larvæ to earthworms and leeches. Some of the small fishes (Johnny darter, stickleback) show little change. Others which attain larger size (crappie) are versatile and sometimes feed as adults on the same foods used when young. The two fishes which are largely vegetarian when adult (carp, sucker) both make their first food largely from entomostracans, then change to insect larvæ, and finally to plants.

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[a] Forbes, S. A.: On the food relations of fresh-water fishes: A summary and discussion; pp. 497-504, 1888.

Though the data from which these conclusions are made are by no means full enough to make very definite generalizations, the general course of events is indicated. The most important foods for young fishes are entomostracans, insects and their larvæ, and amphipods. Forbes[a] discussed changes in foods correlated with increase of age fully.

V. INFLUENCE OF FOOD ON THE SELECTION OF HABITATS.

Shelford (1911a) said "An animal should be associated, first, with breeding conditions; second, with the feeding conditions; third, with conditions affording shelter." Of course no species of fish could persist in a body of water that did not have places suitable for breeding. Most fishes during the breeding season give up feeding more or less and become more bold, thus being less protected. If there must be a choice between reproductive activities and something else, reproduction usually comes first. There is considerable variation in the length of time during which breeding activities dominate all others. Many species lay their eggs and take no more care of the young; some even eat their own eggs or young. Other fishes look after the young until they are able to shift for themselves. A cisco finishes its spawning in a few days; the young of the dogfish are watched by the parents for a couple of months. Aside from the actual time spent in breeding, some antecedent activities are doubtless influenced by preparation for reproduction, but in any of the fishes discussed in this paper breeding and its associated activities do not occupy more than a fourth of each year, usually much less.

Reproductive activities are, then, transitory, but food and shelter are more or less constant necessities. During the greater part of the year the dominant activity of a fish is finding food, and habits of feeding play a considerable part in keeping fishes in particular habitats. Any organism must have a continued supply of materials to furnish substance and energy. If shelter is close to the food supply, so much the better; but if it is not, food must still be sought.

According to the data discussed in section II of this paper, the habitat that affords the largest and most varied food supply is the aquatic vegetation along the shore, and it also furnishes good shelter. More species of fishes frequent the shore vegetation than any other habitat, and they together take a greater variety of food than those in any other place. The habitat most favored by fishes next to the general shore vegetation is the weedy mouths of streams; the third choice is sand and pebble beaches; the fourth, rivers and small streams; and the fifth, the little weedy ponds along shore. The number of fishes occurring in different habitats and their chief foods are shown in Table 6.

The habitats having the greatest variety of food and shelter have the most species of fishes. If there must be a choice between food and shelter, the former is taken. For example, a pebble and sand beach has less shelter and more available food than a rocky beach and is visited by five times as many species of fishes. Forbes (1888) has discussed the dependence of the food of fishes on their structural equipment in a masterly way. It is apparent that structure is of great importance, but behavior must also be considered. If not influenced by other factors, fishes will persistently select certain habitats and foods. The most potent influences in changing foods and feeding habits come with the seasonal cycle and with changes in age. The annual succession of seasons brings breeding, changes in gases and minerals in the water, variations in temperature, fluctuations in food supply and shelter, and other things which require variations in behavior. Young fishes do not have to breed and require different foods from adults. Through all these changing influences, food is in general more important than any other single factor in causing fish to select particular habitats.

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[a] Forbes, S. A.: On the food relations of fresh-water fishes: A summary and discussion, pp. 492-497, 1888.

VI. GENERAL CONSIDERATIONS OF THE FOODS ON THE SHORE FISHES OF LAKES.

The food of the 30 lake fishes reported in this paper shows that most species feed along the shore. Young fishes are found more or less in shallow water everywhere, but most of the adults are more specific in their selection of habitats and for the most part frequent the aquatic vegetation, which furnishes food and shelter. The fishes which are not usually associated with shore vegetation live near the bottom (perch, sucker), on rocky or pebbly shores (miller's thumb, Johnny darter), at the surface (silversides), or in the open water (cisco).

Competition between species for the different kinds of food is usually not very keen. When a particular sort of food is abundant, a number of different fishes may feed upon it, but if it becomes scarce the fishes do not all turn to the same diet for a second choice. This specificity in the selection of food enables different species to live together in the same habitats.

It is important in considering fish foods and the feeding of fishes to keep in mind that habits change as age increases. Forbes (1888) said, "One-celled organisms and Entomostraca are the natural, and practically the only, food of an undifferentiated small fish; and to be at liberty to grow, the fish must either change its food (as is usually done) or must develop a special apparatus (commonly a set of fine gill rakers) for the separation of Entomostraca from the waters in which they swim. A few apparently become vegetarians at once; most pass into or through an insectivorous stage. After this a few become nearly omnivorous, like the bullheads; others learn to depend chiefly on molluscan food—the sheepshead and the redhorse species—but many become essentially carnivorous." The great dependence of many species of young fishes on entomostracans makes them rivals to some extent for the same foods, but, as Forbes pointed out, this is offset in part by the seasonal differences in the time of hatching. Some fishes also begin to eat small dipterous larvæ as soon as they are able to feed. From the data presented in this paper it appears that insect larvæ are of as much importance for young fishes as entomostracans.

Adult fishes fall readily into classes, according to their chief foods—vegetarians, piscivores, insectivores, those that eat entomostracans, and those that feed on mud and sediment. The chief vegetarians in Wisconsin lakes are the carp and sucker. It is an axiom in biology that, in any particular part of the earth, the vegetarians must greatly exceed in numbers the carnivorous animals which feed upon them, and in general this law is fulfilled among the fishes. The insectivorous fishes (basses, darters, etc.) usually secure their food when it is in the larval condition, and, in lakes, adult insects are of much less importance than immature stages. The fishes feeding on entomostraca (cisco, bream, crappie, perch, carp, etc.) are partly adults and partly young fishes which will later turn more to other foods. In spite of the fact that these little crustaceans are an important element in the food of most young fishes, they do not rival insects. The total amount of insect food (36.3 per cent) in Table 1 is nearly twice as great as the total amount of entomostracans (19.1 per cent). The piscivorous species (pike, gar, pickerel, bowfin) depend on small fishes which get their food from plants directly or indirectly through entomostracans or insect eaters. Scavengers (sucker, blunt-nosed minnow, etc.) get organic remains from the mud and débris at the bottom of the lake or among the aquatic plants. Doubtless, fishes affect each other to a considerable extent by eating spawn. The perch in Lake Mendota follow the breeding suckers and ciscoes inshore and eat their eggs. Table 1 shows that four species eat the spawn of other fishes. Without doubt this number could be increased by more extended examinations during breeding seasons.

The nature of the food influences the flavor of fishes, thus enhancing or decreasing their desirability as food for man, and some particular kinds of food seem to make fishes more or less palatable. One of the best food fishes in Wisconsin lakes is the wall-eyed pike, which feeds on fish and frogs. The pickerel is also of good flavor and likewise eats fish, but the bowfin and gar, though they feed mostly on fish, are most undesirable for food. All fishes feeding largely on entomostracans or insects (and which attain sufficient size to be eaten) are of good flavor. Feeders on vegetation or mud are in general less desirable than carnivorous or insectivorous species.

Little is known concerning the amount and variety of food required by fishes. Pütter (1909) did some work along this line, and rations on which certain species thrive have been worked out in hatcheries, but there is no general satisfying knowledge concerning the amount of food required, the variety necessary, the value of different kinds of foods for metabolism, the rate of digestion, the percentage of foods digested, and other matters relating to the value of foods.

In its broad relations the matter presented in this paper is preliminary to more important studies which should be made on the food requirements of fishes. The problem for the fish culturist and scientific investigator involves work in a number of different fields. The food and feeding habits of fishes must be thoroughly known. The work of Forbes and that presented in this paper contribute in this connection to a knowledge of the fishes in the United States. Another line of investigation must be in the chemical nature of foods. Studies are now being carried out by the Wisconsin Geological and Natural History Survey in which adequate quantities of different species of aquatic organisms are being analyzed. It will also be necessary to determine many things relating to the general metabolism of fishes—amount of food necessary, kinds of food necessary, rate of digestion and assimilation, what proportion of food eaten is digested, etc. When all these things are known, it will be possible to ascertain definitely why fishes thrive on certain kinds of foods and fail to do so on others. It will also be possible to prescribe proper rations with some confidence. The recent work on the etiology of beri-beri and the illuminating researches of McCollum and Davis (1915) on the causes of growth open up new possibilities. These investigators have made very exact determinations of the substances and amounts necessary for proper rations, and the methods employed may be applied to fishes with profit.

But the day when we shall know enough to figure out proper rations is far in the future, and in the meantime every effort should be made to find better foods for growing fishes. There is no reason why we should feed flour and liver forever without knowing why. The recent work of Atkins (1908) in which trout were reared on fly larvæ is very suggestive and should be extended. There is no reason why other "natural" foods should not be fed to growing fishes in hatcheries. Entomostracans are easily collected in quantities with a pump or tow net. At some hatcheries (Lyell, 1902) they have been collected at intervals and fed to fry with good results. There is no reason why insect larvæ, snails, amphipods, earthworms, and other abundant living foods should not be more generally collected or reared as food for young fishes.

TABLE 1.—SUMMARY OF FISH FOODS.

[All figures concerning food mean percentages by volume. In the "habitat" column the significance of the numbers is as follows: 1, aquatic vegetation along shore; 2, sand and pebble beaches; 3, rock beaches; 4, bottom of lake everywhere; 5, surface of lake along shore; 6, surface of lake everywhere; 7, open lake; 8, swamp; 9, mouths of streams; 10, river; 11, small ponds; and 12, small streams. These numbers refer to places where collections were actually made; not to the habitats as indicated by the food. The habitats occurring with the greatest frequency are placed first.]

Name.	Number examined.[a]	Average length in mm.	Toad eggs.	Tadpoles.	Frogs.	Fish eggs.	Fish.	Insect eggs.	Diptera larvæ.	Ephemerid nymphs.	Hemiptera nymphs.	Odonata nymphs.	Trichoptera larvæ.
Abramis crysoleucas	57	67.6	......	......	......	......	......	......	3.1	0.3	......	......	......
Ambloplites rupestris	45	72.9	......	......	......	......	2	......	19.1	3.5	......	14.4	2.8
Ameiurus melas	15	118.8	......	......	......	......	......	......	32.6	......	......	.4	.5
Ameiurus nebulosus	50	46.3	......	......	......	......	......	......	24.3	2	......	1.4	......
Amiatus calva	16	467.4	......	......	......	......	90.1	......	......	......	......	......	......
Boleosoma nigrum	50	30.9	......	......	......	......	......	0.1	57.1	1.6	......	......	.1
Catostomus commersonii	34	29.2	......	......	......	......	......	.7	39.9	......	......	......	......
Cottus ictalops	30	39.6	......	......	......	......	......	......	7.5	24	......	......	.1
Cyprinus carpio	42	41.7	......	......	......	......	......	.3	33.6	4.1	1.2	......	......
Esox lucius	39	293.4	......	......	......	......	84	......	.4	8.1	.2	......	......
Etheostoma flabellare	5	37.3	......	......	......	......	......	......	42.7	......	......	......	4.8
Etheostoma iowæ	5	47.8	......	......	......	......	......	......	21	......	......	......	......
Eucalia inconstans	110	29.3	......	......	......	0.2	......	......	21.5	.6	+	......	.9
Eupomotis gibbosus	9	145.7	9.4	......	......	......	......	......	9	.5	......	1	......
Fundulus diaphanus menona	149	40.4	......	......	......	.8	......	......	19.7	2.8	.2	+	......
Labidesthes sicculus	100	33.3	......	......	......	......	......	1.4	3.2	......	.7	......	......
Lepisosteus osseus	10	494.9	......	......	......	......	88.8	......	.1	......	......	10.2	......
Lepomis incisor	149	51	......	......	......	......	......	......	27.2	6.1	.1	2.8	1.2
Micropterus dolomieu	19	72.5	......	......	......	......	14.7	......	15	18.1	......	......	......
Micropterus salmoides	80	66.8	......	......	0.2	......	8.7	......	5.2	15.3	.9	1.3	......
Notropis heterodon	80	34	......	......	......	......	......	.7	12.2	.6	......	......	......
Perca flavescens	115	99.9	......	0.3	......	.2	3	......	17.3	6.4	3.4	4.0	3
Percina caprodes	27	72.9	......	......	......	27.8	......	......	42.2	1.4	3.4	......	5
Pimephales notatus	60	40	......	......	......	......	......	......	14.5	......	......	......	......
Pimephales promelas	3	48.8	......	......	......	......	......	......	......	......	......	......	......
Pomoxis sparoides	66	90.5	......	......	.1	......	7.1	1	14.3	4.6	......	1.5	......
Roccus chrysops	14	65.6	......	......	......	......	4.2	8.6	19.4	......	......	2.8	......
Salmo irideus	1	126.5	......	......	......	......	......	......	25	......	......	......	8
Salvelinius fontinalis	18	103.2	......	......	......	......	......	......	20.1	......	......	......	11.5
Schilbeodes gyrinus	55	32.7	......	......	......	......	......	......	10	18.7	......	1	.5
Stizostedion vitreum	11	440	......	......	9.1	......	90.9	......	......	......	......	......	......
Umbra lima	110	39.9	......	......	......	......	......	......	15	.5	......	1	1.5
Average, all species	......	....	.3	......	.3	.9	12.3	.4	17.4	2.8	.3	1.4	1.2

[a] Total number of fishes examined, 1,576: Toad eggs, 0.3; fishes, 13.5; insect larvæ, 24.8; insect pupæ, 6.3; adult insects, 5.2; hydrachnids, 0.5; large Crustacea, 13.3; Entomostraca, 19.1; Mollusca, 2; Oligochætes, 3.5; leeches, 0.4; rotifers, 0.2; plants, 4.2; débris, etc., 2.6.

TABLE 1.—SUMMARY OF FISH FOODS—Continued.

Name.	Number examined.	Average length in mm.	Sialis larvæ.	Coleoptera larvæ.	Unidentified larvæ.	Diptera pupæ.	Trichoptera pupæ.	Coleoptera pupæ.	Adult Diptera.	Adult Ephemerida.	Adult Hemiptera.	Adult Orthoptera.
Abramis crysoleucas	57	67.6			0.3	5.7			0.1			
Amblopiites rupestris	45	72.9	2.2	0.5	.5	9.6			4.8		1.2	
Ameiurus melas	15	118.8		.4	1.3	4.2			4.3		.6	
Ameiurus nebulosus	50	46.3		.5		2.1			1.7			
Amiatus calva	16	467.4										
Boleosoma nigrum	50	30.9			.3	1.4			.1			
Catostomus commersonii	34	29.2				2.4			.4		+	
Cottus ictalops	30	39.6							1			
Cyprinus carpio	42	41.7		.5		3.5	1.6	1.6	2.9			
Esox lucius	39	293.4				1			.1			
Etheostoma flabellare	5	37.3							.2			
Etheostoma iowæ	5	47.8		16								
Eucalia inconstans	110	29.3				9.1			7.3		.3	
Eupomotis gibbosus	9	145.7	1.1		+	.2			.3	0.7	1.5	
Fundulus diaphanus menona	149	40.4		.6	.1	1.7			2.7		+	
Labidesthes sicculus	100	33.3			1.3	16.4			25.2			
Lepisosteus osseus	10	494.9							1			
Lepomis incisor	149	51			.6	6			1.3		1.4	
Micropterus dolomieu	19	72.5				7.6			10.7		18.2	
Micropterus salmoides	80	66.8		.2	.1	3.1			6.3	.1	18.5	
Notropis heterodon	80	34		+	.1	3.9			8.1			
Perca flavescens	115	99.9	.4	.2		1.2			.4		1.4	
Percina caprodes	27	72.9				3.7			.6		.1	
Pimephales notatus	60	40				5.8			4.5			
Pimephales promelas	3	48.8				79.3						
Pomoxis sparoides	66	90.5			1	4.6			4.8		1.7	
Roccus chrysops	14	65.6				5.8			1.2		7.1	
Salmo irideus	1	126.5				7						
Salvelinus fontinalis	18	103.2		2.3		18.4			.8		.4	3.7
Schilbeodes gyrinus	55	32.7		5.4	4	4.4			.5			1.8
Stizostedion vitreum	11	440										
Umbra limi	110	39.9		1.6	2.3	2.1			5		1.8	.1
Average, all species			.1	.9	.3	6.3	+	+	2.6	+	1.1	

Name	Number examined.	Average length in mm.	Adult Hymenoptera.	Adult Odonata.	Adult Trichoptera.	Adult Lepidoptera.	Adult Coleoptera.	Aptera.	Unidentified insects.	Spiders.	Mites.	Millipeds.
Abramis crysoleucas	57	67.6							0.2		0.4	
Amblopiites rupestris	45	72.9	1.3				1.1		5.3		.2	
Ameurus melas	15	118.8		0.8								
Ameiurus nebulosus	50	46.3	.4	.1			.5		1.7		.4	
Amiatus calva	16	467.4										
Boleosoma nigrum	50	30.9									+	
Catostomus commersonii	34	29.2					.2				.1	
Cottus ictalops	30	39.6										
Cyprinus carpio	42	41.7							.6		1.8	
Esox lucius	39	293.4										
Etheostoma flabellare	5	37.3										
Etheostoma iowæ	5	47.8										
Eucalia inconstans	110	29.3							1.4		.6	
Eupomotis gibbosus	9	145.7			1.1		6.4					
Fundulus diaphanus menona	149	40.4					.1	0.3				
Labidesthes sicculus	100	33.3	3.1						1.3	0.3	+	
Lepisosteus osseus	10	494.9										
Lepomis incisor	149	51	+						.5		.7	
Micropterus dolomieu	19	72.5			3.2							
Micropterus salmoides	80	66.8	.6	1.3	1.3							
Notropis heterodon	80	34	.5		.5		.8		.3		.5	
Perca flavescens	115	99.9			+		+				.1	
Percina caprodes	27	72.9							1.2			
Pimephales notatus	60	40									+	
Pimephales promelas	3	48.8									1.6	
Pomoxis sparoides	66	90.5				1.4					.3	
Roccus chrysops	14	65.6			.1							
Salmo irideus	1	126.5					3					10
Salvelinus fontinalis	18	103.2	.1				1.3		.3		.4	.4
Schilbeodes gyrinus	55	32.7		.6			.3		.4		+	
Stizostedion vitreum	11	440										
Umbra limi	110	39.9					3	.4	.6	.1	1.2	
Average, all species			.2	.1	.1	+	.5	+	.4	+	.2	.3

TABLE 1.—SUMMARY OF FISH FOODS—Continued.

Name.	Number examined.	Average length in mm.	Crayfishes.	Isopods.	Amphipods.	Ostracods.	Copepods.	Cladocerans.	Gastropods.	Sphæridæ.	Oligochætes.	Leeches.
Abramis crysoleucas	57	67.6	......	......	2.2	1.9	16.5	57.6	0.4	0.7	......	......
Ambloplites rupestris	45	72.9	16.1	......	1.4	.3	.3	4.3	......	......	3	......
Ameriurus melas	15	118.8	6.1	......	.2	1.6	.7	3.5	3.7	......	21.4	3
Ameiurus nebulosus	50	46.3	......	......	11.4	6.7	8.4	33.1	.1	......	2.1	......
Amiatus calva	16	467.4	9.4	......	......	......	......	......	......	......	......	......
Boleosoma nigrum	50	30.9	......	......	5.1	.5	7.4	5.6	......	......	18.4	......
Catostomus commersonii	34	29.2	......	......	......	16.8	14.8	3.6	......	......	11.5	......
Cottus ictalops	30	39.6	......	......	59.1	.6	1.2	.1	......	......	.7	3
Cyprinus carpio	42	41.7	......	......	6.9	7	10.4	3.6	6.9	......	2.8	......
Esox lucius	39	293.4	......	......	2.5	......	......	2.6	......	.2	......	2.5
Etheostoma flabellare	5	37.3	......	......	48	......	......	.2	......	......	3	......
Etheostoma iowæ	5	47.8	......	......	58	......	......	......	3	......	1.6	......
Eucalia inconstans	110	29.3	......	3.4	1.2	3.2	19.3	16	3.6	.1	1.1	......
Eupomotis gibbosus	9	145.7	......	......	9	1.3	......	......	25.8	......	......	2.8
Fundulus diaphanus menona	149	40.4	......	......	14.1	15.8	4.9	15.3	3.5	.4	2	......
Labidesthes sicculus	100	33.3	......	......	......	+	8.7	32	......	......	......	......
Lepisosteus osseus	10	494.9	......	......	......	......	......	......	......	......	......	......
Lepomis incisor	149	51	......	+	14.4	.4	7.9	16.6	4.5	......	.1	.6
Micropterus dolomieu	19	72.5	......	......	......	......	......	3.4	......	......	4.6	......
Micropterus salmoides	80	66.8	2.6	......	13.9	.1	2.9	15.1	+	......	.7	+
Notropis heterodon	80	34	......	......	.1	.5	11	33.4	......	......	2.1	......
Perca flavescens	115	99.9	......	......	24.5	.4	7.8	17.6	3.7	.1	.4	......
Percina caprodes	27	72.9	......	......	6.6	+	.2	.2	......	......	......	2
Pimephales notatus	60	40	......	......	......	.3	2.6	25.1	......	......	7	......
Pimephales promelas	3	48.8	......	......	.3	......	2.6	......	......	......	6	......
Pomoxis sparoides	66	90.5	......	......	10.6	12	21.6	13.6	......	......	......	......
Roccus chrysops	14	65.6	......	......	5	.4	29.6	16.3	......	......	......	......
Salmo irideus	1	126.5	......	......	42	......	......	......	5	......	......	......
Salvelinus fontinalis	18	103.2	......	1.3	35.5	......	......	......	1.4	......	......	......
Schilbeodes gyrinus	55	32.7	......	......	10.3	4	7.9	6.1	.1	......	18.3	......
Stizostedion vitreum	11	440	......	......	......	......	......	......	......	......	......	......
Umbra limi	110	39.9	......	......	6.5	23.1	3.6	1.3	2.3	.1	2.9	1.1
Average, all species	......	....	1.1	.1	12.1	3	6	10.1	2	+	3.5	.4

Name.	Number examined.	Average length in mm.	Nematodes.	Rotifers.	Sponges.	Protozoans.	Unidentified eggs.	Plant remains.	Algæ.	Silt and débris.	Unidentified.	Habitats.
Abramis crysoleucas	57	67.6	......	+	......	1.0	......	2.9	1.6	2.2	......	9, 1
Ambloplites rupestris	45	72.9	......	......	......	......	......	2.8	.5	1.2	......	1, 10
Ameiurus melas	15	118.8	......	......	......	......	......	6.4	.9	6.3	......	9, 1
Ameiurus nebulosus	50	46.3	......	+	......	+	......	.9	+	2.3	......	1, 9
Amiatus calva	16	467.4	......	......	......	......	......	......	......	......	......	1
Boleosoma nigrum	50	30.9	......	......	......	......	......	......	+	3.1	......	2
Catostomus commersonii	34	29.2	......	0.2	......	1.3	......	......	3	3.6	......	9, 2
Cottus ictalops	30	39.6	......	......	......	......	......	.1	1	.2	......	3, 2
Cyprinus carpio	42	41.7	......	1.1	......	+	......	4.9	.8	1.5	......	1, 11
Esox lucius	39	293.4	......	......	......	......	......	......	......	1.2	......	1
Etheostoma flabellare	5	37.3	......	......	......	......	......	1	......	......	......	3
Etheostoma iowæ	5	47.8	......	......	......	......	......	......	......	.4	......	10, 2
Eucalia inconstans	110	29.3	+	1.1	......	......	......	3.2	1.2	3.7	......	11, 12
Eupomotis gibbosus	9	145.7	......	......	0.8	......	......	21.9	3.6	2.8	......	1
Fundulus diaphanus menona	149	40.4	+	......	......	......	0.8	5.5	.9	4.2	......	1, 10, 12, 2
Labidesthes sicculus	100	33.3	......	+	......	+	......	......	4	1.6	......	5
Lepisosteus osseus	10	494.9	......	......	......	......	......	......	......	......	......	1, 10
Lepomis incisor	149	51	+	+	......	......	......	2.9	2.3	2.2	......	1, 10
Micropterus dolomieu	19	72.5	......	......	......	......	......	.6	.8	1.5	......	......
Micropterus salmoides	80	66.8	......	......	......	......	......	1.2	.7	.1	......	1, 2, 9, 10
Notropis heterodon	80	34	......	2.2	......	......	......	3.9	11.7	6.5	......	1, 2, 12
Perca flavescens	115	99.9	......	......	......	+	+	.8	.7	1.1	......	4, 1, 9
Percina caprodes	27	72.9	......	......	......	......	......	3.3	1.7	5.7	......	2
Pimephales notatus	60	40	......	......	......	+	......	.9	19.3	20	......	1, 2, 9, 10
Pimephales promelas	3	48.8	......	......	......	......	......	......	1.3	8.3	......	12
Pomoxis sparoides	66	90.5	......	......	......	......	......	1.3	......	.1	......	1, 2, 9
Roccus chrysops	14	65.6	......	......	......	......	......	......	......	......	......	6, 1, 4, 7
Salmo irideus	1	126.5	......	......	......	......	......	......	......	......	......	12
Salvelinus fontinalis	18	103.2	......	......	......	......	......	.1	......	......	......	12
Schilbeodes gyrinus	55	32.7	......	......	......	......	......	5.9	.1	3	......	9
Stizostedion vitreum	11	440	......	......	......	......	......	......	......	......	......	1
Umbra limi	110	39.9	0.4	.2	......	.2	......	2.5	11.1	1.4	3.8	8, 11, 12, 1
Average, all species	......	....	+	.2	+	+	+	2.2	2	2.5	.1	......

TABLE 2.—SHOWING FOODS EATEN BY SEVEN SPECIES OF FISHES COLLECTED TOGETHER AT STATION 5, AUGUST 18, 1915.

Name.	Number examined.	Average length.	Dipterous larvæ.	Chironomid larvæ.	Probezzia larvæ.	Tanypus carneus larvæ.	Tanypus decoloratus larvæ.	Protenthes culiciformis larvæ.	Chironomus fulviventris larvæ.	Chironomus lobiferus larvæ.	Chironomus digitatus larvæ.	May-fly nymphs.	Bætisca nymphs.	Ecdyurus maculipennis nymphs.
Abramis crysoleucas	7	46.7	......	......	0.7	2.9	......	......	......	......	......	......	......	......
Boleosoma nigrum	1	30	......	......	15	25	......	......	......	......	......	10	......	......
Micropterus salmoides	15	52.4	1	......	......	......	......	......	0.3	......	......	4	18.6	......
Perca flavescens	2	124.3	......	......	......	......	......	......	......	......	......	......	5	......
Pimephales notatus	2	38	......	5	......	......	......	......	......	......	......	......	......	......
Schilbeodes gyrinus	24	24.3	......	......	......	......	1	1	1.3	0.8	0.6	1.9	.6	0.7
Number of fish eating	......	......	1	1	2	2	1	1	2	1	1	3	3	1

Name.	Number examined.	Average length.	Caenis diminuta nymphs.	Corixa nymphs.	Damsel-fly nymphs.	Enallagma antennatum nymphs.	Chironomus lobiferus pupa.	Adult insects.	Chironomus adults.	Corixa adults.	Micronecta adults.	Mites.	Hyalella.
Abramis crysoleucas	7	46.7	......	......	......	......	......	2.1	......	......	......	0.8	12.1
Micropterus salmoides	15	52.4	2.9	0.9	......	......	0.7	......	......	35	0.3	......	25
Perca flavescens	2	124.3	10	......	......	......	......	......	2.5	51.5	......	......	30.7
Schilbeodes gyrinus	24	24.3	20.5	......	0.8	1.5	......	......	......	......	......	......	15.5
Number of fish eating	......	......	3	1	1	1	1	1	1	2	1	1	4

Name.	Number examined.	Average length.	Ostracods.	Cyclops.	Canthocamptus.	Cladocerans.	Bosmina.	Camptocercus.	Pleuroxus.	Chydorus.	Eurycercus.	Simocephalus.	Planorbis.
Abramis crysoleucas	7	46.7	2.9	23.6	1.4	10	10.1	......	1	2.1	......	5	......
Boleosoma nigrum	1	30	15	......	......	......	......	......	......	20	......	......	......
Micropterus salmoides	15	52.4	......	......	......	......	......	......	......	......	......	11	......
Perca flavescens	2	124.3	......	2.5	......	......	......	......	......	......	......	......	......
Pimephales notatus	2	38	3.5	2.5	......	......	......	......	......	......	4	......	......
Roccus chrysops	1	29	......	65	......	......	35	......	......	......	......	......	......
Schilbeodes gyrinus	24	24.3	1.9	.7	......	......	......	1.1	......	.2	......	.3	0.2
Number of fish eating	......	......	4	5	1	1	2	1	1	3	1	3	1

Name.	Number examined.	Average length.	Oligochætes.	Rotifers.	Protozoa.	Plant remains.	Myriophyllum.	Wolffia.	Seeds.	Free-swimming algæ.	Filamentous algæ.	Sand.	Silt and débris.
Abramis crysoleucas	7	46.7	......	0.6	......	3.4	......	2.1	0.6	2.1	7.6	......	4.3
Boleosoma nigrum	1	30	15	......	......	......	......	......	......	......	......	......	......
Micropterus salmoides	15	52.4	......	......	......	......	......	......	.2	......	......	......	......
Perca flavescens	2	124.3	......	......	+	......	......	......	......	.2	......	......	......
Pimephales notatus	2	38	......	......	......	......	2.5	......	......	......	......	......	82.5
Schilbeodes gyrinus	24	24.3	37.9	......	......	......	1.2	.8	9.2	......	......	0.1	......
Number of fish eating	......	......	2	1	1	1	2	2	3	2	1	1	2

TABLE 3.—SHOWING FOODS EATEN BY FOUR SPECIES OF FISHES COLLECTED TOGETHER AT STATION 18, JULY 3, 1915.

Name.	Number examined.	Average length in mm.	Helea larvæ.	Chironomid larvæ.	Chironomus lobiferus larvæ.	Chironomus abbreviatus larvæ.	Chironomus digitatus larvæ.	Chironomus viridis larvæ.	Chironomus palliatus larvæ.	Probezzia glaber larvæ.	Protenthes culiciformis larvæ.	Procladius sp. No. 3 larvæ.	Cricotopus trifasciatus larvæ.	Palpomyia longipennis larvæ.
Amblopliteś rupestris	19	53.6	......	......	0.7	......	1	......	......	......	......	......	3.1	23.1
Fundulus diaphanus menona	11	47.3	0.2	3	3.6	0.2	......	......	......	0.5	0.3	19.7	......	......
Lepomis incisor	10	45.4	......	......	......	......	4.4	0.3	6.3	......	......	12	3.4	.2
Notropis heterodon	11	39.9	......	......	3.4	......	......	......	......	......	......	......	4.5	......
Number of fish eating	......	......	1	1	3	1	2	1	1	1	1	2	3	2

Name.	Number examined.	Average length in mm.	Tanypus monilis larvæ.	Ecdyurus maculipennis nymph.	Enallagma hageni nymph.	Enallagma antennatum nymph.	Damsel-fly nymph.	Ichythricha sp. larva.	Leptocerus dilutus larva.	Agraylea multipunctata larva.	Peltodytes edentulus larva.	Caterpillar.	Chironomus lobiferus pupa.	Chironomus tentans pupa.
Ambloplites rupestris	19	53.6	......	7	2.7	25	4.2	0.1	2.7	......	......	1	5.4	......
Lepomis incisor	10	45.4	0.3	......	......	......	......	......	......	0.2	0.2	......	2.7	1.2
Number of fish eating	......	......	1	1	1	1	1	1	1	1	1	1	2	1

Name.	Number examined.	Average length in mm.	Palpomyia longipennis pupa.	Palpomyia longipennis adult.	Minute insects.	Corixa adult.	Mites.	Crustacea.	Dikerogammarus.	Hyalella.	Ostracod.	Cladocera.	Eurycercus.
Ambloplites rupestris	19	53.6	5.3	11.4	......	0.7	0.5	0.1	......	......	0.3	......	7.6
Fundulus diaphanus menona	11	47.3	......	......	......	......	......	......	0.1	49.1	......	......	22.6
Lepomis incisor	10	45.4	......	......	......	......	3.2	......	......	9.8	......	8.4	47.1
Notropis heterodon	11	39.9	......	......	1.3	......	1	......	......	......	......	......	5
Number of fish eating	......	......	1	1	1	1	3	1	1	2	1	1	4

Name.	Number examined.	Average length in mm.	Bosmina.	Ceriodaphnia.	Daphnia.	Daphnia hyalina.	Pleuroxus.	Chydorus.	Chydorid.	Alona.	Oligochætes.	Wolffia.	Filamentous algæ.
Ambloplites rupestris	19	53.6	......	......	......	......	......	......	......	......	2.6	......	1
Lepomis incisor	10	45.4	......	......	......	......	......	......	......	0.1	......	......	......
Notropis heterodon	11	39.9	1	0.5	5.4	42.6	0.1	13.5	1.4	......	......	3.2	16.8
Number of fish eating	......	......	1	1	1	1	1	1	1	1	1	1	2

TABLE 4.—SHOWING FOODS EATEN BY FOUR SPECIES OF FISHES COLLECTED TOGETHER AT STATION 28, SEPTEMBER 17, 1915.

Name.	Number examined.	Average length.	Fish remains.	Sunfish.	Minnows and fish.	Probezzia glaber larva.	Probezzia pallida larva.	Tipula abdominalis larva.	Cænis diminuta nymph.	Corixa adult.	Crayfish.
Amiatus calva	4	469.7	48.5	43.5							7.5
Ameiurus melas	13	124.7				4	4	1			
Esox lucius	14	451.8	50	50							
Pomoxis sparoides	57	77.2			50				3	10	
Number of fish eating			2	2	1	1	1	1	1	1	1

Name.	Number examined.	Average length.	Cyclops.	Chydorids.	Daphnia.	Planorbis.	Physa.	Plant remains.	Lemna.	Nostoc.	Fine débris.
Ameiurus melas	13	124.7				25	30	10	1	15	10
Pomoxis sparoides	57	77.2	1	1	35						
Number of fish eating			1	1	1	1	1	1	1	1	1

TABLE 5.—VARIATION OF FOODS AT DIFFERENT PLACES AND TIMES, IN COLLECTIONS MADE DURING 1915.

Species.	Chief items of food eaten.	Number localities.	Number times collected.	Number of chief foods.
Abramis crysoleucas	Cladocera (2), Hyalella, Cyclops	3	4	3
Ambloplites rupestris	Crayfish (5) May-fly nymphs, oligochætes, caddis-fly larvæ, chironomid larvæ (3), chironomid pupæ (2).	7	13	6
Ameiurus melas	Chironomid larvæ, caterpillar snails, oligochætes	3	4	4
Ameiurus nebulosus	Ostracods, adult insects, amphipods	3	4	3
Amiatus calva	Crayfish, fish remains (2)	2	3	2
Boleosoma nigrum	Chironomid larvæ (8), oligochætes (3)	8	11	2
Catostomus commersonii	Chironomid larvæ, Ostracods, Cyclops (2)	2	4	3
Cottus ictalops	Hyalella (10), Dikerogammarus	8	11	2
Cyprinus carpio	Chironomid larvæ, Ostracods, Hyalella, plant remains	3	4	4
Esox lucius	Hyalella (2), fish remains	5	11	2
Etheostoma flabellare	Chironomid larvæ, Hyalella	3	3	2
Etheostoma iowæ	Hyalella	1	2	1
Eucalia inconstans	Chironomid larvæ (2), Chydorus, fine débris	3	5	3
Eupomotis gibbosus	Toad eggs, Sialis larvæ, chironomid larvæ, Hyalella, Ceratophyllum	3	5	5
Fundulus diaphanus menona.	Chironomid larvæ (5), amphipods (4), Ostracods (2), oligochætes, cladocera, fine débris.	11	14	6
Labidesthes sicculus	Chironomid pupa (5), Cladocera (2), Chironomid adult (2)	8	9	3
Lepisosteus osseus	Fish remains	3	3	1
Lepomis incisor	Chironomid larvæ (6), amphipods (3), chironomid pupæ (2), snails, fine débris, Aphanothece, copepods, cladocera.	15	17	8
Micropterus dolomieu	Insect larvæ (2), fish remains, adult insect	4	4	3
Micropterus salmoides	Adult insects (4), amphipods (2), copepods, cladocera, fish remains, insect larvæ, plant remains, crayfish.	12	15	8
Notropis heterodon	Chironomid larvæ (2). copepods (2), cladocera (2), chironomid pupæ, chironomid adult, oligochætes, filamentous algæ.	6	10	7
Perca flavescens	Hyalella (3), cladocerans (3), insect larvæ (3), insect adults, fish remains.	7	11	5
Percina caprodes	Chironomid larvæ (3), fish eggs	3	4	2
Pimephales notatus	Filamentous algæ (3), oligochætes, chironomid larvæ, chironomid adult, cladocerans, fine débris.	8	10	6
Pimephales promelas	Chironomid larvæ	1	1	1
Pomoxis sparoides	Fish remains, chironomid pupæ, adult insect, Ostracods, daphnia	9	10	5
Roccus chrysops	Copepods (4), chirnomid larvæ, insect adult, fish remains, cladocera.	3	7	5
Salmo irideus	Amphipods	1	1	1
Salvelinus fontinalis	Chironomid pupæ, amphipods	2	2	2
Schilbeodes gyrinus	Insect larvæ (2), adult insect, amphipods, cladocera, oligochætes	2	6	5
Schizostedium vitreum	Fish remains (2), fish, and frogs	2	3	2
Umbra limi	Ostracods (2), amphipods (2), chironomid larvæ (2), earthworm, plant remains.	7	8	5
Total		159	215	117

TABLE 6.—NUMBER OF SPECIES OF FISHES FOUND IN DIFFERENT HABITATS AND THE CHIEF ITEMS OF DIET EATEN IN EACH IN 1915.

Habitat.	Number of species.	Chief items of diet, and number of species eating each.
Shore vegetation	22	Dipterous larvæ, 5; fish, 4; cladocerans, 4; adult Hemiptera, 2; copepods, 2; dipterous pupæ, 1; ephemerid nymphs, 1; gastropods, 1; amphipods, 1; ostracods, 1.
Sand and pebble beaches	11	Dipterous larvæ, 4; adult Hemiptera, 2; amphipods, 2; cladocerans, 2; copepods, 1.
Mouths of streams	11	Dipterous larvæ, 4; cladocerans, 3; ephemerid nymphs, 1; adult Hemiptera, 1; amphipods, 1; copepods, 1.
Rivers	7	Dipterous larvæ, 3; fish, 1; adult Hemiptera, 1; amphipods, 1; cladocerans, 1.
Small streams	7	Dipterous larvæ, 2; amphipods, 2; dipterous pupæ, 1; cladocerans, 1; ostracods, 1.
Shore ponds	3	Dipterous larvæ, 2; ostracods, 1.
Swamps	2	Cladocerans, 1; ostracods, 1.
Rocky beaches	2	Amphipods, 2.
Bottom anywhere	2	Amphipods, 1; copepods, 1.
Surface of shore water	1	Cladocerans, 1.
Surface of open lake	1	Copepods, 1.

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THE FISHES OF KENTUCKY AND TENNESSEE: A DISTRIBUTIONAL CATALOGUE OF THE KNOWN SPECIES

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INTRODUCTION.

While engaged in studying the considerable collection of fishes obtained by the writer in east Tennessee in 1893, in connection with investigations carried on in that region for the United States Bureau of Fisheries (then United States Fish Commission), it was necessary to consult all the available literature pertaining to the ichthyology not only of that region but of the entire Mississippi drainage. This naturally led to the accumulation of a large number of notes and memoranda relating to the fishes of the region, particularly those of the Tennessee and Cumberland Rivers. In order that these data and the labor incident to their preparation may not be lost, it seems worth while to assemble and put them in a form whereby they may be available for others who may study the fishes of Kentucky and Tennessee. It is believed they will prove of particular value to those interested in questions of geographic distribution.

With this thought in mind, an attempt has been made in the present paper to summarize our knowledge of the fish faunas of the Tennessee and Cumberland River Basins and of the other waters in the States of Kentucky and Tennessee.

A brief historical résumé of the systematic and faunistic work which has been done on the fishes of this region is given.

So far as the writer has been able to discover from an examination of available literature, the first man to collect and study the fishes of Kentucky and Tennessee was that enthusiastic, albeit somewhat eccentric naturalist, Constantine Samuel Rafinesque.

This indefatigable student of nature came to Lexington, Ky., in 1818, where, through the good offices of his friend John D. Clifford, he secured the professorship of botany and natural history in Transylvania University, located at Lexington.

Here, as Prof. Call has well said, Rafinesque "was in a veritable new world; the plants and animals had never been either collected or studied; the hand of the husbandman had not yet destroyed much of the primitive forest; untold wealth of natural forms appealed to Rafinesque, the Nature-lover, as they have rarely appealed to any man. To-day even, in the face of the check which specialization furnishes to scientific investigators, few men could withstand this lavish display of new and unknown forms! They were on every hand, in every glade and mead, in every brook and spring, the creeks, the rivers, the very rocks themselves. Like a schoolboy, Rafinesque searched and found, studied, described, drew, sent abroad, the wonderful forms in which he, almost alone, now reveled." Rafinesque remained at Lexington eight years. In the early fall of 1825, upon returning to Lexington from one of his long collecting trips, Rafinesque found that, during his absence, his effects had been removed from his room in the college and stored in the garret, and the room which he had formerly occupied turned over to another professor. This was an indignity which our sensitive naturalist could not endure, and he at once left Lexington, as he says, "with anathemas on the university and curses on the president, both of which were speedily fulfilled, for the university building burned down within six months and the president died within a year."

His stay at Lexington was long enough, however, to enable him to collect, study, and describe many of the animals and plants of the region. His first paper on the fishes, containing descriptions of 26 new species from the Ohio, appeared in 1818 in the American Monthly Magazine and Critical Review. This was followed in the same year by a second paper in the same magazine, in which he listed 22 species from the Ohio, and that by a third paper describing three new genera and species of fishes, which appeared in the Journal of the Academy of Natural Sciences of Philadelphia (vol. 1, 1818). Then followed another short article in the American Monthly Magazine and Critical Review for November, 1818. Next came a short paper in the Journal de Physique for June, 1819, in which 9 species were described as new. Then followed a series of articles in the Western Review and Miscellaneous Magazine from December, 1819, to November, 1820.

During the period of publication of these magazine articles Rafinesque had the matter made up in octavo forms and reprinted from the same type, the pagination, however, differing slightly.[a] This reprint was issued by Rafinesque in 1820 under the title "Ichthyologia Ohiensis." Practically all the matter[b] contained in the "Ichthyologia" appeared first in the magazine and the new species really date from it.

All of the Ichthyologia was therefore written at Lexington, but on his numerous collecting trips Rafinesque doubtless sometimes went far afield. He evidently found the Falls of the Ohio an excellent place to observe and collect fishes, for he records many species from that place. Among the waters he mentions specifically are the Kentucky, Licking, Big Sandy, Green, Cumberland, Tennessee, Little, Salt, and Elkhorn Rivers, Salt Creek, a pond near Lexington, and springs and caves near Lexington. It is probable that he collected in all these waters and many others in Kentucky.

Rafinesque was therefore the first naturalist to study the fishes of Kentucky and Tennessee. Our first knowledge of the ichthyological fauna of that region dates from Rafinesque's arrival at Lexington in 1818, and to the Transylvania University belongs the honor of having had as a member of its faculty the all-round naturalist who was the first to collect and study the fishes beyond the Alleghenies. To that institution must attach also the stigma of having driven from its halls the only man in its faculty whose name has survived to this day.

The second person to collect any of the fishes of the Tennessee Basin was Charles A. Hentz, of Florence, Ala. Some time prior to July, 1845, Mr. Hentz collected a number of fishes in Alabama waters, chiefly from the Tennessee River and its small tributaries in the vicinity of Florence. These he forwarded, together with drawings which he made of them, to Dr. D. H. Storer, of Boston, who described them at the meetings of the Boston Society of Natural History, July 2 and 16, 1845 (Storer, 1845). The number of species described from the Tennessee was four, of which two are still regarded as good.

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[a] For these statements I am indebted to Dr. Richard Ellsworth Call's excellent reprint of the Ichthyologia Ohiensis.

[b] Only the Supplement, Corrections and Additions, and Index (pp. 85–90) did not appear in the periodical.

The next collector who paid any attention to the fishes of the Tennessee was Dr. Newman, of Huntsville, Ala., who placed in the hands of Prof. Louis Agassiz "a collection of not less than 33 species from the same water system." These were described by Prof. Agassiz in the American Journal of Arts and Sciences in 1854 (Agassiz, 1854).

The next naturalist to collect the fishes of the Tennessee Basin and the first, Rafinesque excepted, to study his own collections from that region was Prof. Edward Drinker Cope. In the summer and fall of 1867, Prof. Cope made large collections in the western part of Virginia from the Roanoke, James, Kanawha, and Holston Rivers. Prof. Cope says, "The fishes of the Roanoke were taken in the seventh month, those of the James and Kanawha in the eighth and ninth, and those of the Holston in the tenth, 1867."

The results of these field investigations were published by Prof. Cope in several papers, the titles of which are given in the bibliography (pp. 312, 313).

For the next nine years little, if any, ichthyological exploration was conducted in this region. In the summer of 1876, however, Prof. David Starr Jordan began making those collecting trips in Kentucky, Tennessee, Virginia, North Carolina, Georgia, and Alabama which were continued at intervals for 12 years and which added so greatly to our knowledge of the fishes of that region. Prof. Jordan was then (until 1879) professor of natural sciences in the Northwestern Christian University (now Butler University) at Irvington, near Indianapolis; and professor of natural sciences 1879–1885, and president 1885–1891 of the University of Indiana.

During the summer of 1876 he was accompanied by one of his students, Charles Henry Gilbert, and by Alembert Winthrop Brayton, then teacher of natural sciences in the Indianapolis high school. Collecting was done in various streams in Tennessee and North Carolina. Prof. Jordan, accompanied by Mr. Gilbert and Dr. Brayton, again collected in the same States in the summer of 1877. Very extensive collections were made, which formed the basis of a valuable paper by Jordan and Brayton.

In the summer of 1878 the writer was a member of a party of students led by Jordan, Brayton, and Gilbert on a walking trip through eastern Kentucky and Tennessee, western North Carolina, and northern Georgia, during which he made his first acquaintance with the fishes of that region.

In May, 1883, Dr. Jordan, assisted by Joseph Swain (then a senior at Indiana University, now president of Swarthmore College), again led a party of students from Indiana University into Kentucky and made collections of the fishes of the streams of Whitley County in that State.

The next year Prof. Charles H. Gilbert and Prof. Joseph Swain made considerable collections in east Tennessee and Kentucky and in northern Alabama. All the waters examined are in the Tennessee or the Cumberland Basin. They are all listed elsewhere in this paper.

In the summer of 1888 various places in the upper Tennessee Basin were visited by Dr. David Starr Jordan, Prof. Oliver Peebles Jenkins, and the writer, and large collections were made, which were reported on by Dr. Jordan.

In the spring of 1889 and the autumn of 1890 Prof. Philip H. Kirsch, at that time superintendent of schools, Columbia, Ky., made collections of fishes in the streams of Clinton County, Ky.

During the period from August 18 to September 9, 1891, Prof. Kirsch again collected fishes in Kentucky and Tennessee waters, this time from the southern tributaries of the Cumberland between Nashville, Tenn., and the crossing of the Cincinnati Southern Railroad at Burnside, Ky.

In the summer of 1890 Mr. Albert Jefferson Woolman, a former student of the writer at the Indiana State Normal School, and later of Dr. Jordan's at Indiana University, from which institution he had just graduated, examined many of the streams of Kentucky in the interests of the United States Fish Commission. He was assisted by Hiram W. Monical, of Brooklyn, Ind., and Charles O. Chambers, of Van Wert, Ohio, also students in the University of Indiana. The field work began July 23 and ended September 10. Mr. Monical assisted from July 23 to August 13 and Mr. Chambers from August 13 to September 10.

In September and October, 1893, the writer examined many streams and springs in east Tennessee in the interests of the fish-cultural work of the United States Fish Commission. In that work he was assisted by the late Dr. Josiah T. Scovell, of Terre Haute, Ind., and Dr. Revere R. Gurley, scientific assistant, United States Fish Commission. The work began at Knoxville September 27 and ended at Cumberland Gap October 17. Considerable collections of fishes were made, which have only recently been reported on by Evermann and Hildebrand.[a]

In May, 1898, the writer spent several days at Louisville, Ky., studying the Ohio shad and at the same time making collections of the other species of food fishes then found at the Falls of the Ohio. These collections were reported on by the author in 1902. Little or no ichthyological work of a faunistic character has been done in Kentucky and Tennessee since this work in 1898.

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[a] Bulletin, U. S. Bureau of Fisheries, vol. xxxiv, 1914 (Sept. 21, 1916), pp. 431–452.

LIST OF WATERS EXAMINED.

Following is a list, approximately complete, of all the waters of the Tennessee and Cumberland River systems and of other waters in the States of Kentucky and Tennessee from which collections of fishes have been made.

The names of the streams or other waters are arranged alphabetically for ready reference. The particular place at which the stream was examined is indicated with some detail, the names of the collectors are given, and, when known, the exact date when the collecting was done, and, finally, reference to the paper in which the species collected were recorded.

Arnwine, or Matlock, Spring, near Mount Verd, 5 miles north of Athens, Tenn. (Evermann, Scovell, and Gurley, collectors, October 5, 1893; Evermann and Hildebrand, 1916).

Ball Creek, near Tazewell, Tenn. (Gurley, collector, October 18, 1893; Evermann and Hildebrand, 1916).

Bayou de Chien, just north of Moscow, Ky., also 3 miles west of that place (Woolman and Monical, collectors, July 29, 1890; Woolman, 1892).

Bear Creek, Smyth County, Va. (Cope, collector, October, 1867; Cope, 1869).

Beaver Creek, 6 miles north of Glasgow, Ky. (Woolman and Monical, collectors, August 6, 1890; Woolman, 1892).

Beaver Creek, above and below McCackney's milldam in Wayne County, Ky. (Kirsch, collector, September 3, 1891; Kirsch, 1893).

Big Barren River, three-fourths mile northeast of Bowling Green, Ky. (Woolman and Monical, collectors, August 1, 1890; Woolman, 1892).

Big Creek, at Big Creek, Ky. (Woolman and Chambers, collectors, August 22, 1890; Woolman, 1892).

Big Nance Creek, at Courtland, Ala., and for 3 miles down (Kirsch, Andrews, and Jones, collectors, June 7, 1889; Gilbert, 1891).

Big Sandy River (Rafinesque, 1818).

Big Sandy River, at its mouth (Gilbert and Henshall, collectors, 1888; Woolman, 1892).

Big South Fork of the Cumberland, on the shoals near the mouth of Rock Creek, 7 miles west of Whitley station, Ky. (Kirsch, collector, September 7, 1891; Kirsch, 1893).

Big Spring, 8 miles southwest of Greenville, Tenn. (Scovell and Gurley, collectors, October 10, 1893; Evermann and Hildebrand, 1916).

Big Sycamore Creek, near Tazewell, Tenn. (Gurley, collector, October 18, 1893; Evermann and Hildebrand, 1916).

Blaine Creek, 2 miles west of the railroad bridge at Catalpa, Ky. (Woolman and Chambers, collectors, September 8, 1890; Woolman, 1892).

Briar Creek, near Pleasant View in Whitley County, Ky. (Jordan and Swain, collectors, May, 1883; Jordan and Swain, 1883; Woolman, 1892).

Brimstone Creek, for a distance of a mile near New River station, Tenn. (Kirsch, collector, September 9, 1891; Kirsch, 1893).

Bull Creek, 4 miles west of Hyden, Ky. (Woolman and Chambers, collectors, August 23, 1890; Woolman, 1892).

Callahan Springs, 5 miles northwest of Knoxville, Tenn. (Evermann, Scovell, and Gurley, collectors, September 27, 1893; Evermann and Hildebrand, 1916).

Canada Creek, at a point 8 miles above its mouth, Wayne County, Ky. (Kirsch, collector, September 4, 1891; Kirsch, 1893).

Caney Fork River, 1 mile west of Lancaster, Tenn. (Kirsch, collector, August 24, 1891; Kirsch, 1893).

Caves, near Lexington, Ky. (Rafinesque, 1820).

Chickamauga Creek, at Lee and Gordon's mill, Ga. (Evermann, Scovell, and Gurley, collectors, September 30, 1893; Evermann and Hildebrand, 1916).

Chilohoway Creek, Smyth County, Va. (Cope, 1869).

Clear Creek, 1 mile west of the railroad station at Wildie, or 10 miles southwest of Livingston, Ky. (Woolman and Monical, collectors, 1890; Woolman, 1892).

Clear Fork of Cumberland River, near Pleasant View, Whitley County, Ky. (Jordan and Swain, collectors, May, 1883; Jordan and Swain, 1883; Woolman, 1892).

Clinch River, tributaries near Clinton, Tenn. (Gilbert and Swain, collectors, 1884; Gilbert, 1887).

Clinch River, at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, collectors, October 12, 1893; Evermann and Hilderbrand, 1916).

Clinch River (tributary of), Tenn. (Cope, 1870).

Coon Creek, near Zebulon, Ky. (Woolman and Chambers, collectors, September 5, 1890; Woolman, 1892).

Cox Creek, near Florence, Ala. (Gilbert and Swain, collectors, 1884; Gilbert, 1888).

Craigmiles Springs, 1 mile north of Cleveland, Tenn. (Evermann, Scovell, and Gurley, collectors, October 3, 1893; Evermann and Hildebrand, 1916).

Crawfish Springs, Ga. (Evermann, Scovell, and Gurley, collectors, September 30, 1893; Evermann and Hildebrand, 1916).

Cypress Creek, near Florence, Ala. (Gilbert and Swain, collectors, 1884; Gilbert, 1887).

Cypress Creek, near Florence, Ala. (Kirsch, Andrews, and Jones, collectors, June 5, 1889; Gilbert, 1891).

Cumberland River (Rafinesque, 1820).

Cumberland River (headwaters), in Campbell County, Tenn. (Cope, 1870); at Cumberland Falls (Evermann, collector, June, 1878).

Cumberland River, 1¼ miles south of Kuttawa, Ky. (Woolman and Monical, collectors, July 26, 1890; Woolman, 1892).

Cumberland River, both above and below the mill just south of Barbourville, Ky. (Woolman and Chambers, collectors, August 14, 1890; Woolman, 1892).

Cumberland River, just below the bridge between the railroad station and the town of Pineville, Ky. (Woolman and Chambers, collectors, August 15, 1890; Woolman, 1892).

Cumberland River, at the lock and dam at the mouth of Willis Creek in Clinton County, Ky. (Kirsch, collector, September 1, 1891; Kirsch, 1893).

Cutshin Creek, 4 miles east of Hyden, Ky., and 3 miles from the point where this creek flows into the Middle Fork (Woolman and Chambers, collectors, August 24, 1890; Woolman, 1892).

Davis Springs, 1½ miles northwest of Greenville, Tenn. (Scovell and Gurley, collectors, October 10, 1893; Evermann and Hildebrand, 1916).

Drake Creek, 8 miles southeast of Bowling Green, Ky. (Woolman and Monical, collectors, August 2, 1890; Woolman, 1892).

Duck River, near Columbia, Tenn. (Gilbert and Swain, collectors, 1884; Gilbert, 1891).

Eagle Creek, for a distance of 2 miles near Olympus, Tenn. (Kirsch, collector, August 27, 1891; Kirsch, 1893).

Eastaunaula Creek, near Athens, Tenn. (Evermann, Scovell, and Gurley, collectors, October 6, 1893; Evermann and Hildebrand, 1916).

Elk River, at Estill Springs, Tenn. (Jordan and Gilbert, collectors, 1876; Jordan, 1878).

Elkhorn River, Ky. (Rafinesque, 1820).

Fountain Head Springs, at Fountain City near Knoxville, Tenn. (Evermann and Gurley, collectors, September 27, 1893; Evermann and Hildebrand, 1916).

French Broad River, in Madison County, N. C. (Cope, 1870); at Alexander's, N. C. (Evermann, collector, July 4, 1878).

Gap Creek, near Pleasant View, Whitley County, Ky. (Jordan and Swain, collectors, May, 1883; Jordan and Swain, 1883).

Goose Creek, near Garratsville, Ky., 15 miles from its mouth (Woolman and Chambers, collectors, August 20, 1890; Woolman, 1892).

Green's pond, or Newman Spring, 6 miles southeast of Chattanooga, Tenn. (Evermann, Scovell, and Gurley, collectors, September 29, 1893; Evermann and Hildebrand, 1916).

Green River (Rafinesque, 1820).

Green River, 5 miles southwest of Greensburg, Ky. (Woolman and Monical, collectors, August 7, 1890; Woolman, 1892).

Green River, one-half mile east of Greensburg, Ky. (Woolman and Monical, collectors, August 8, 1890; Woolman, 1892).

Hector Creek, 5 miles west of Big Creek, Ky. (Woolman and Chambers, collectors, August 21, 1890; Woolman, 1892).

Horse Creek, 2 miles above its mouth near Garratsville, Ky. (Woolman and Chambers, collectors, August 20, 1890; Woolman, 1892).

Hungrysmother Creek, Smyth County, Va. (Cope, 1869).

Indian Creek, Clinton County, Ky. (Kirsch, collector, 1889–90; Kirsch, 1892).

Indian Creek, near Cumberland Gap, Tenn. (Gurley, collector, October 17, 1893; Evermann and Hildebrand, 1916).

Island Creek, 1 mile from its mouth and 2 miles east of Pikeville, Ky. (Woolman and Chambers, collectors, September 1, 1890; Woolman, 1892).

John Creek, at Zebulon, Ky. (Woolman and Chambers, collectors, September 5, 1890; Woolman, 1892).

Julians Spring, about 8 miles southeast of Cleveland, Tenn. (Evermann, Scovell, and Gurley, collectors, October 4, 1893; Evermann and Hildebrand, 1916).

Kentucky River (Rafinesque, 1820).

Kentucky River, near Estill (Rafinesque, 1820).

King Solomon's Cave, at Cumberland Gap, Tenn. (Evermann, Scovell, and Gurley, collectors, October 14, 1893; Evermann and Hildebrand, 1916).

Left Troublesome Creek, at Hindman, Ky. (Woolman and Chambers, collectors, August 28, 1890; Woolman, 1892).

Levisa Fork of the Big Sandy River, at Pikeville, Ky (Woolman and Chambers, collectors, September 2, 1890; Woolman, 1892).

Little Barren River, from the mill at Osceola, Ky., one-half mile downstream (Woolman and Monical, collectors, August 6, 1890; Woolman, 1892).

Licking River (Rafinesque, 1820).

Licking River, at Farmer, Rowan County, Ky. (Woolman and Chambers, collectors, September 9, 1890; Woolman, 1892).

Little Rockcastle River, 6 miles northeast of Livingston, Ky. (Woolman and Monical, collectors, August 12, 1890; Woolman, 1892).

Little River, Ky. (Mr. Wilkins, collector, Rafinesque, 1820).

Little Sandy River, at its mouth (Gilbert and Henshall, collectors, 1888; Woolman, 1892).

Little South Fork of the Cumberland, at the mouth of Canada Creek, Wayne County, Ky. (Kirsch, collector, September 5, 1891; Kirsch, 1893).

Lot Creek, 2 miles west of Hazard and 1 mile from its mouth (Woolman and Chambers, collectors, August 26, 1890; Woolman, 1892).

Lyon Creek, near the insane asylum, 5 miles west of Knoxville, Tenn. (Evermann, Scovell, and Gurley, collectors, September 28, 1893; Evermann and Hildebrand, 1916).

Mammoth Cave, Ky. (De Kay, collector; D. H. Storer, 1846).

Mammoth Cave, Ky. (Alpheus Hyatt, collector; Putnam, 1872).

Mallett Creek, near Hillsboro, Ala. (Kirsch, Andrews, and Jones, collectors, June 8, 1889; Gilbert, 1891).

Matlock, or Arnwine Spring, near Mount Verd, 5 miles north of Athens, Tenn. (Evermann, Scovell, and Gurley, collectors, October 5, 1893; Evermann and Hildebrand, 1916).

Mayfield Creek, at the "Old Mill Pond" and the "Basin," one-half mile east and three-fourths mile south of the railroad station at Hickory Grove, Ky. (Woolman and Monical, collectors, July 28, 1890; Woolman, 1892).

Middle Fork of the Kentucky River, 4 miles north of Hyden, Ky. (Woolman and Chambers, collectors, August 22, 1890; Woolman, 1892).

Newman Spring, or Greens Pond, 6 miles southeast of Chattanooga, Tenn. (Evermann, Scovell, and Gurley, collectors, September 29, 1893; Evermann and Hildebrand, 1916).

New River, at New River station, Tenn. (Kirsch, collector, September 9, 1891; Kirsch, 1893).

Nickajack Cave and Stream, at Shellmound, 20 miles southwest of Chattanooga, Tenn. (Evermann, Scovell, and Gurley, collectors, October 2, 1893; Evermann and Hildebrand, 1916).

Nolichucky River, at Loves Ferry south of Greenville, Tenn. (Evermann, Scovell, and Gurley, collectors, October 11, 1893; Evermann and Hildebrand, 1916).

North Fork of the Holston River, near Saltville, Va. (Cope, collector, October, 1867; Cope, 1869).

North Fork of the Kentucky River, just south of Hazard, Ky. (Woolman and Chambers, collectors, August 25, 1890; Woolman, 1892).

Norvel Spring, 7 miles east of Athens, Tenn. (Evermann, Scovell, and Gurley, collectors, October 7, 1893; Evermann and Hildebrand, 1916).

Obeys River, for a distance of 1½ miles near Olympus, Tenn. (Kirsch, collector, August 28, 1891; Kirsch, 1893).

Obion River, 12 miles southeast of Moscow, Ky. (Woolman and Monical, collectors, July 30, 1890; Woolman, 1892).

Ohio River at the Falls (Rafinesque, 1818–20; Evermann, collector, March, 1886, and May, 1898; Evermann, 1902).

Ohio River (Rafinesque, 1818–20).

Ohio River, at Cincinnati (Duméril, 1870).

Otter Creek, near Jones milldam in Wayne County, Ky. (Kirsch, collector, September 2, 1891; Kirsch, 1893).

Ousley Spring, 8 miles from Tazewell, Tenn. (Evermann, Scovell, and Gurley, collectors, October 12, 1893; Evermann and Hildebrand, 1916).

Paynes Spring, 2 miles north of Cleveland, Tenn. (Evermann, Scovell, and Gurley, collectors, October 3, 1893; Evermann and Hildebrand, 1916).

Pigeon Roost Creek, near Pulaski, Tenn. (Gilbert and Swain, collectors, 1884; Gilbert, 1891).

Pistol Creek, at Maryville, Tenn. (Evermann, collector, October 10, 1893; Evermann and Hildebrand, 1916).

Pitman Creek, 3 miles west of Greensburg, Ky., and 8 miles above its mouth (Woolman and Monical, collectors, August 9, 1890; Woolman, 1892).

Pond near Lexington, Ky. (William M. Clifford, collector, 1818; Rafinesque, 1820).

Pond Creek, 2 miles from Rockport, Ky., or one-half mile above its mouth (Woolman and Monical, collectors, July 25, 1890; Woolman, 1892).

Powell River, 8 miles south of Cumberland Gap, Tenn. (Woolman and Chambers, collectors, August 16, 1890; Woolman, 1892).

Read's spring, 7 miles north of Chattanooga, Tenn. (Evermann, Scovell, and Gurley, collectors, October 1, 1893; Evermann and Hildebrand, 1916).

Redbird Creek (south fork of the Kentucky), 1 mile west of Big Creek, Ky. (Woolman and Chambers, collectors, August 22, 1890; Woolman, 1892).

Richland Creek, near Pulaski, Tenn. (Gilbert and Swain, collectors, 1884; Gilbert, 1891).

Richland Creek, 1½ miles west of Barbourville, Ky., near the mouth of Smoky Fork (Woolman and Chambers, collectors, August 14, 1890; Woolman, 1892).

Right fork of Beaver Creek, at Lackey, Ky. (Woolman and Chambers, collectors, August 29, 1890; Woolman, 1892).

Roaring Fork, 5 miles north of Greenville, Tenn. (Scovell and Gurley, collectors, October 10, 1893; Evermann and Hildebrand, 1916).

Roaring River, a few miles from Windle, Tenn. (Kirsch, collector, August 30, 1891; Kirsch, 1893).

Robinson Creek, near Robinson, Ky. (Woolman and Chambers, collectors, August 30, 1890; Woolman, 1892).

Rockcastle River, near Livingston, Ky. (Jordan and Gilbert, collectors, 1876; Woolman, 1892).

Rockcastle River, just below the railroad bridge (Gilbert and Swain, collectors, 1884; Woolman, 1892).

Rockcastle River, one-half mile above the mouth of Little Rockcastle River (Woolman and Monical, collectors, August 12, 1890; Woolman, 1892).

Rockcastle River, 2 miles from Livingston, Ky. (Woolman and Monical, collectors, August 13, 1890; Woolman, 1892).

Rock Creek, in its lower course near Whitley railway station, Ky. (Kirsch, collector, September 7, 1891; Kirsch, 1893).

Rolling Fork of Salt River, near New Market, Ky. (Gilbert and Swain, collectors, 1884; Woolman, 1892).

Rolling Fork of Salt River, 1¼ miles east of the railroad station at Booth, Ky. (Woolman and Monical, collectors, July 24, 1890; Woolman, 1892).

Rolling Fork of Salt River, near New Haven, Ky. (Gilbert and Swain, collectors, 1884; Woolman, 1891).

Rough Creek, below the mill at Hartford, Ky. (Woolman and Monical, collectors, July 25, 1890; Woolman, 1892).

Round Lick Creek, at Watertown, Tenn. (Kirsch, collector, August 22, 1891; Kirsch, 1893).

Salt Creek, Ky. (Rafinesque, 1820).

Salt River, Ky. (Rafinesque, 1820).

Sandy River (Rafinesque, 1820).

Shoal Creek, near Florence, Ala. (Gilbert and Swain, collectors, 1884; Gilbert, 1887).

Shoal Creek, near Florence, Ala. (Gilbert and Swain, collectors, 1884; Gilbert, 1891).

Shelby Creek, near its mouth near Robinson, Ky. (Woolman and Chambers, collectors, August 30, 1890; Woolman, 1892).

Slate Creek, Ky. (Mr. Owings, collector; Rafinesque, 1820).

Smith Fork of Caney Fork River, 1 mile above the railroad bridge at Lancaster, Tenn. (Kirsch, collector, August 24, 1891; Kirsch, 1893).

Smoky Fork of Richland Creek, a half mile above its mouth near Barbourville, Ky. (Woolman and Chambers, collectors, August 14, 1890; Woolman, 1892).

South Fork of Cumberland River, in Campbell County, Tenn. (Cope, 1870).

South Fork of the Kentucky River (Redbird Creek), 1 mile west of Big Creek, Ky. (Woolman and Chambers, collectors, August 22, 1890; Woolman, 1892).

Springs near Lexington, Ky. (Rafinesque, 1820).

Spring Branch, at Tuscumbia, Ala. (Kirsch, Andrews, and Jones, collectors, June 6, 1889; Gilbert, 1891).

Spring Creek near Hot Springs, N. C. (Jordan, Brayton, and Gilbert, collectors, 1877 and 1878; Jordan, Jenkins, and Evermann, collectors, 1888; Jordan and Brayton, 1878; and Jordan, 1889).

Spring Creek, 3½ miles northeast of Courtland, Ala. (Kirsch, Andrews, and Jones, collectors, June 7 1889; Gilbert, 1891).

Spring Creek, at Huntsville, Ala. (Kirsch, Andrews, and Jones, collectors, May 27, 1889; Gilbert, 1891).

Spring Creek, at Netherland, Overton County, Tenn. (Kirsch, collector, August 25, 1891; Kirsch, 1893).

Spring Creek, at Springcreek station, Tenn., 12 miles from its mouth (Kirsch, collector, August 21, 1891; Kirsch, 1893).

Stiths Springs, 1 mile south of Cleveland, Tenn. (Evermann, Scovell, and Gurley, collectors, October 4, 1893; Evermann and Hildebrand, 1916).

Stone River, near Nashville, Tenn. (Gilbert and Swain, collectors, 1884; Gilbert, 1887).

Straight Creek, 2 miles above its mouth, near Pineville, Ky. (Woolman and Chambers, collectors, August 15, 1890; Woolman, 1892).

Sturgeon Creek, near Travelers Rest, Ousley County, Ky. (Gilbert and Swain, collectors, 1884; Gilbert, 1887).

Tellico River, at Tellico Plains (Evermann, Scovell, and Gurley, collectors, October 7 and 8, 1893; Evermann and Hildebrand, 1916).

Tennessee River (Rafinesque, 1820; Cope, 1867a).

Tennessee River, near Florence, Ala. (Charles A. Hentz, collector; Storer, 1845).

Tennessee River, near Huntsville, Ala. (Dr. Newman, collector; Agassiz, 1854; Dumèril, 1870).

Tennessee River, at the mouth of Lyon Creek, 5 miles west of Knoxville, Tenn. (Evermann, Scovell, and Gurley, collectors, September 28, 1893; Evermann and Hildebrand, 1916).

Tennessee River, 3 miles above Paducah, Ky. (Woolman & Monical, collectors, July 28, 1890; Woolman, 1892).

Tradewater River, near Dawson Springs, Ky. (Woolman and Monical, collectors, July 26, 1890; Woolman, 1892).

Triplet Creek, a half mile west of the railroad station at Farmer, Ky., and about the same distance from the mouth of the creek (Woolman and Chambers, collectors, September 9, 1890; Woolman, 1892).

Troublesome Creek, near Dwarf, Ky., at the crossing of the Hazard and Hindman road, 12 miles northeast of Hazard, Ky. (Woolman and Chambers, collectors, August 28, 1890; Woolman, 1892).

Tumbling Creek, near Saltville, Va. (Cope, 1869).

Tuscumbia Spring, at Tuscumbia, Ala. (Gilbert and Swain, collectors, 1884; Gilbert, 1887; Evermann, collector, January 8, 1901).

Veta Wright Creek, 3 miles south of Decatur, Ala. (Kirsch, Andrews, and Jones, collectors, June 1, 1889; Gilbert, 1891).

Warm Springs Creek, in Madison County, N. C. (Cope, 1870).

Well near Bowling Green, Ky. (J. E. Younglove, collector; Putnam, 1872).

Well at Lebanon, Wilson County, Tenn. (J. M. Safford, collector; Putnam, 1872).

Well near Moulton, Ala. (Thomas Peters, collector; Putnam, 1872).

West Fork of Stone River, near Murfreesboro, Tenn. (Kirsch, collector, August 20, 1891; Kirsch, 1893).

Willis Creek, at its mouth in Clinton County, Ky. (Kirsch, collector, September 1, 1891; Kirsch, 1893).

Wolf River, 3 miles north of Byrdstown, Tenn. (Kirsch, collector, August 28, 1891; Kirsch, 1893).

Wolf Creek, near Pleasant View, Whitley County, Ky. (Jordan and Swain, collectors, May, 1883; Jordan and Swain, 1883; Woolman, 1892).

Yellow Creek, near Pleasant View, Whitley County, Ky. (Jordan and Swain, collectors, May, 1883; Jordan and Swain, 1883).

BIBLIOGRAPHY.

In the following pages is given in chronological sequence a list of the papers of a faunistic nature dealing with the fishes of Kentucky and Tennessee. Following the title of each paper is a list of the species mentioned in it. For the sake of completeness in giving the contents of some of the earlier papers long since out of print and now almost if not quite impossible to obtain, all the species recorded are here listed, whether from the region covered by the present paper or not.

The statement is usually given in tabular form and shows (1) the page on which the species is recorded, (2) the name under which it was recorded, (3) the present identification, and (4) the particular stream or locality from which it was recorded. In giving the localities the exact words of the author have been used whenever it seemed desirable to do so. The names of species described as new are printed in *italics*.

1818. C. S. Rafinesque.

Discoveries in Natural History, made during a Journey through the Western Region of the United States. <American Monthly Magazine and Critical Review, vol. III, no. 5, pp. 354-356, 1818.

This is a letter by Rafinesque to Samuel L. Mitchill, president, and the other members of the New York Lyecum of Natural History, dated at Louisville, Ky., July 20, 1818. It names 13 genera and 26 species of fishes. The names used were regarded as provisional, and some of them were afterwards changed.

The list is as follows:

Page.	Species as recorded.	Present identification.	Locality.
354	*Perca salmonea*	Stizostedion vitreum	Ohio River.
354	*Perca chrysops*	Roccus chrysops	Do.
354	*Sciæna grunniens*	Aplodinotus grunniens	Do.
354	*Sciæna caprodes*	Percina caprodes	Do.
354	*Bodianus calliurus*	Micropterus dolomieu	Do.
354	*Sparus cyanelus*	Apomotis cyanellus	Do.
354	*Sparus nigropunctatus*	Pomoxis annularis	Do.
354	*Silurus punctatus*	Ictalurus punctatus	Do.
355	*Silurus olivaris*	Leptops olivaris	Do.
355	*Silurus amblodon*	do	Do.
355	*Catostomus bubalus*	Ictiobus bubalus	Do.
355	*Catostomus erythrurus*	Moxostoma aureolum	Do.
355	*Catostomus macropterus*	(?)	Do.
355	*Catostomus duquesnei*	Placopharynx duquesnei	Do.
355	*Clupea heterurus*	Dorosoma cepedianum	Do.
355	*Clupea alosoides*	Hiodon alosoides	Do.
355	*Glossodon harengoides*	Hiodon tergisus	Do.
355	*Glossodon heterurus*	do	Do.
355	*Hydrargyra dinema*	Notropis atherinoides	Do.
355	*Hydrargyra notata*	Pimephales notatus	Do.
355	*Hydrargyra amblops*	Hybopsis amblops	Do.
355	*Lepisosteus fluviatilis*	(?)	Do.
355	*Polyodon folium*	Polyodon spathula	Do.
355	*Polyodon pristis*	(?)	Do.
355	*Acipenser platorhynchus*	Scaphirhynchus platorhynchus	Do.
355	*Silurus pallidus*	Ictalurus punctatus	Do.

1818a. C. S. Rafinesque.

Further Discoveries in Natural History, made during a Journey through the Western Region of the United States. <American Monthly Magazine and Critical Review, vol. III, no. 6, pp. 445-447, 1818.

This title adds 8 genera and 22 species names to the previous list. The list is as follows:

Page.	Species as recorded.	Present identification.	Locality.
445	*Lepisosteus platostomus*	Lepisosteus platostomus	Ohio River
445	*Lepisosteus stenorhynchus*	(?)	Do.
445	*Anguilla laticauda*	Anguilla chrisypa	Do.
445	*Cyprinus fasciolaris*	Erimyzon sucetta oblongus	Do.
445	*Cyprinus trachiaphas*	(?)	Do.
446	*Exoglossum argentum*	(?)	Do.
446	*Olmerus albula*	(?)	Do.
446	*Bodianus calliops*	Macropterus dolomieu	Do.
446	*Pogostoma leucops*	(?)	Do.
446	*Esox vittatus*	Lucius lucius	Do.
446	*Esox fasciolaris*	Lucius vermiculatus	Do.
446	*Catostomus amisopterus*	(?)	Do.
446	*Catostomus amblodon*	(?)	Do.
447	*Catostomus velifer*	Carpiodes velifer	Do.
447	*Glossodon chrysops*	(?)	Do.
447	*Clupea chrysochloris*	Pomolobus chrysochloris	Do.
447	*Silurus pallidus*	Ictalurus punctatus	Do.
447	*Silurus cerulescens*	do	Do.
447	*Glanis limosus*	Leptops olivaris	Do.
447	*Accipenser heptipus*	Acipenser rubicundus	Do.
447	*Dinoctus truncatus*	(?)	Do.
447	*Litholepis adamantinus*	Lepisosteus tristœchus	Do.

1818b. C. S. Rafinesque.

Description of three new genera of Fluviatile Fish, *Pomoxis*, *Sarchirus*, and *Exoglossum*. Read December 1 and 8. <Journ. Acad. Nat. Sci. Phila., vol. 1, 1818, pp. 417–419.

In this paper Rafinesque describes as new the genera *Pomoxis*, *Sarchirus*, and *Exoglossum* and lists the following species from the Ohio:

Page.	Species as recorded.	Present identification.	Locality.
417, pl. 17, fig. 1	*Pomoxis Annularis*	Pomoxis annularis	Ohio River at the falls.
419, pl. 17, fig. 2	*Sarchirus Vittatus*	Lepisosteus osseus	Lower parts of the Ohio.
420, pl. 17, fig. 3	*Exoglossum (Hypentelium) macropterum.*	Hypentelium nigricans	Falls of the Ohio.

1818c. C. S. Rafinesque.

Further Account of Discoveries in Natural History in the Western States, by Constantine Samuel Rafinesque, Esq. Communicated in a letter from that gentleman to the editor, Lexington, October, 1818. <American Monthly Magazine and Critical Review, November, 1818.

The following names occur in this letter:

Page.	Species as recorded.	Present identification.	Locality.
41	Pomoxis annularis	Pomoxis annularis	Ohio River at the falls.
41	*Noturus flavus*	Noturus flavus	Do.
41	Sarchirus vittatus	Lepisosteus osseus	Lower parts of the Ohio.

1819. C. S. Rafinesque.

Prodrome de 70 nouveaux genres d'animaux découverts dans l'intérieur des Etats-Unis d'Amérique durant l'année 1818. <Jour. de Physique, de Chimie et d'Histoire Naturelle et des Arts, etc., tome 88, pp. 417–429, Paris, June, 1819. See also, Isis, Litterarischer Anzeiger, pp. 236–244, Leipzig, 1820.

In this paper Rafinesque described as new nine species from the Ohio and its tributaries in Kentucky, as follows:

Page.	Species as recorded.	Present identification.	Locality.
419	*Amblodon grunniens*	Aplodinotus grunniens	Ohio River.
419	*Etheostoma flabellaris*	Etheostoma flabellare	Tributaries of the Ohio.
420	*Lepomis cyanellus*	Apomotis cyanellus	Ohio River.
420	*Lepomis macrochira*	Lepomis macrochirus	Ohio and Licking Rivers.
421	*Noturus luteus*	Noturus flavus	Ohio River.
421	*Amblodon bubalus*	Ictiobus bubalus	Do.
421	*Cycleptus nigrescens*	Cycleptus elongatus	Do.
421	(?) *Amblodon niger*	do	Do.
421	*Notemigonus auratus*	Abramis crysoleucas	Falls of the Ohio.

1820. C. S. RAFINESQUE.

Description of the Silures, or Catfishes of the River Ohio. <Quarterly Journal of Science, Literature, and Arts, Royal Institution, vol. IX, p. 48, London, 1820.

In this paper, which Rafinesque refers to as his monography of the catfishes, are described 11 species and 6 varieties of catfishes. The following were described from the Kentucky-Tennessee region:

Page.	Species as recorded.	Present identification.	Locality.
51	*Silurus melas*	Ameiurus melas	Ohio River.
51	*Silurus maculatus*	Ictalurus punctatus	Do.
51	Silurus pallidus	do	Do.
51	Silurus cerulescens	do	Do.
51	*Silurus argentinus*	do	Do.
51	*Silurus argyrus*	do	Do.
48	*Silurus argyrus* var. *erythroptera*	do	Do.
48	*Silurus argyrus* var. *marginatus*	do	Do.
48	*Silurus argyrus* var. *lateralis*	do	Do.
48	*Silurus argyrus* var. *leucoptera*	do	Do.
48	*Silurus lividus* var. *fuscatus*	Ameiurus natalis	Do.
51	Silurus cupreus	do	Do.
50	Silurus nebulosus	Leptops olivaris	Do.
50	*Silurus viscosus*	do	Do.
50	Silurus limosus	do	Do.

1820*a*. C. S. RAFINESQUE.

Ichthyologia Ohiensis, or Natural History of the Fishes Inhabiting the River Ohio and its Tributary Streams, preceded by a physical description of the Ohio and its branches. By C. S. Rafinesque, Professor of Botany and Natural History in Transylvania University, author of the Analysis of Nature, etc., etc., member of the Literary and Philosophical Society of New York, the Historical Society of New-York, the Lyceum of Natural History of New-York, the Academy of Natural Sciences of Philadelphia, the American Antiquarian Society, the Royal Institute of Natural Sciences of Naples, the Italian Society of Arts and Sciences, the Medical Societies of Lexington and Cincinnati, etc., etc. The art of seeing well, or of noticing and distinguishing with accuracy the objects which we perceive, is a high faculty of mind, unfolded in few individuals, and despised by those who can neither acquire it, nor appreciate its results. Lexington, Ky. Printed for the author by W. G. Hunt. (Price, one dollar.) 1820.

As already stated, all of the Ichthyologia except the Supplement, the Corrections and Additions, and the Index first appeared in the Western Review and Miscellaneous Magazine, a journal published at Lexington from November, 1819, to December, 1820. Rafinesque had the matter arranged in octavo forms and reprinted at the close of the year 1820 as the "Ichthyologia Ohiensis."

The following tabular statement, for which we are indebted to Dr. Call, correlates the pagination of the Western Review and Miscellaneous Magazine with that of the Ichthyologia Ohiensis.

Volume.	No.	Date.	Serial No.	Pages Western Review and Miscellaneous Magazine.	Pages Ichthyologia Ohiensis.
I	5	December, 1819	I	305-313	1-13
I	6	January, 1820	II	361-377	13-29
II	1	February, 1820	III	49-57	29-37
II	3	April, 1820	IV	169-177	37-45
II	4	May, 1820	V	235-242	45-53
II	5	June, 1820	VI	299-307	53-60
II	6	July, 1820	VII	355-363	60-69
III	3	October, 1820	VIII	165-173	69-77
III	4	November, 1820	IX	244-252	77-84

The total number of nominal species recorded in the Ichthyologia is 113. Of these, 5 (*Salmo Alleganiensis*, *Salmo nigricans*, *Rutilus compressus*, *Pristis Mississippiensis*, and *Proceros maculatus*) are extra limital, and 10 (*Perca nigropunctata*, *Aplocentrus calliops*, *Pogastoma leucops*, *Catostomus anisopturus*, *Catostomus niger*, *Catostomus fasciolaris*, *Catostomus* (?) *megastomus*, *Pylodictis limosus*, *Accipenser macrostomus*, and *Dinectus truncatus*) were based on drawings furnished him by Mr. Audubon. These drawings were, in most respects, grotesque in character and not meant to represent any fishes that Audubon had actually seen. Nevertheless, Audubon, playing upon Rafinesque's credulity, and "with a suave manner and with an air of absolute truthfulness," presented them to Rafinesque, who, with evident hesitation yet with entire confidence in the great ornithologist, proceeded in good faith to describe them.

It is said that Rafinesque visited Audubon at Henderson, Ky. After spending the evening in pleasant conversation and exchange of views regarding the natural history of the region in which they were, Rafinesque was shown to his room, which was in the garret. While preparing to retire Audubon heard a commotion in Rafinesque's room, and, rushing up stairs, saw the eccentric naturalist in night clothes, and with Audubon's favorite violin grasped firmly in his hand, striking wildly at a bat which was flying about the room, and which Rafinesque declared must be a "new species." Audubon arrived on the scene just in time to see the violin broken. Perhaps he never quite forgave his guest for this injury to his violin. Perhaps it was this incident, together with Rafinesque's childlike credulity, which induced Audubon to play the practical joke. However that may be, the result has been the adding of several names to ichthyological literature which have caused much concern to later ichthyologists. In the present paper it is thought best merely to mention these names, as above. This leaves 98 species which properly belong in the Ichthyologia. They are all given in the following tabular statement. In the first column is given the pagination of the Western Review and Miscellaneous Magazine in arabic and that of the Ichthyologia in *italic* figures. The volume of the magazine is also shown.

Volume and page.	Species as recorded.	Present identification.	Locality.
I, 369, *21*	Perca Salmonea	Stizostedion vitreum	Ohio, Licking, and Kentucky Rivers.
I, 370, *22*	Perca chrysops	Roccus chrysops	Ohio River chiefly in the lower parts.
I, 372, *24*	Amblodon grunniens	Aplodinotus grunniens	Ohio, Tennessee, Cumberland, and Kentucky Rivers.
I, 374, *26*	*Calliurus Punctulatuse*	Micropterus dolomieu	Falls of the Ohio.
I, 375, *27*	Icthelis macrochira	Lepomis macrochirus	Ohio and Green Rivers.
I, 376, *28*	Icthelis cyanella	Apomotis cyanellus	Falls of the Ohio.
I, 376, *28*	*Icthelis melanops*	do	Tributary streams of the Ohio, Kentucky, and Licking Rivers.
I, 377, *29*	*Icthelis enythrops*	Ambloplites rupestris	No stream mentioned.
II, 49, *29*	Icthelis aurita	Lepomis auritus	Rivers, creeks, and ponds of Kentucky.
II, 49, *29*	*Icthelis megalotis*	Lepomis megalotis	Kentucky, Licking, and Sandy Rivers, etc.
II, 50, *30*	*Lepomis pallida*	Micropterus salmoides	Ohio River.
II, 51, *31*	*Lepomis trifasciata*	Micropterus dolomieu	Ohio River and many other streams.
II, 51, *31*	*Lepomis flexuolaris*	do	Ohio and tributaries.
II, 52, *32*	*Lepomis salmonea*	do	Ohio, Kentucky, Green, and Licking Rivers, etc.
II, 52, *32*	*Lepomis notata*	do	Do.
II, 52, *32*	*Lepomis ictheloides*	Ambloplites rupestris	Kentucky River and tributary streams.
II, 53, *33*	Pomoxis annularis	Pomoxis annularis	Falls of the Ohio.
II, 56, *36*	*Etheostoma calliura*	Micropterus dolomieu	Ohio and Salt Rivers, etc.
II, 56, *36*	*Etheostoma flabellata*	Etheostoma flabellare	Falls of the Ohio.
II, 169, *37*	*Etheostoma nigra*	Boleosoma nigrum	Green River.
II, 169, *37*	*Etheostoma blennioides*	Diplesion blennioides	Ohio River.
II, 170, *38*	Etheostoma caprodes	Percina caprodes	Ohio, Cumberland, Tennessee, Green, Licking, and Kentucky Rivers.
II, 171, *39*	Pomolobus chrysochloris	Pomolobus chrysochloris	Falls of the Ohio.
II, 172, *40*	*Dorosoma notata*	Dorosoma cepedianum	Do.
II, 172, *40*	*Notemigonus auratus*	Abramis crysoleucas	Ohio and Kentucky Rivers.
II, 174, *42*	*Hyodon amphiodon*	Hiodon alosoides	Lower parts of the Ohio.
II, 174, *42*	*Hyodon heterurus*	Hiodon tergisus	Ohio River and tributary streams.
II, 175, *43*	*Hyodon vernalis*	do	All over the Ohio and even at Pittsburgh.
II, 175, *43*	Hyodon clodalis (misprint for tergisus, p. 88).	do	Ohio River as far as Pittsburgh.
II, 236, *46*	Minulus dinemus	Notropis atherinoides	Ohio River.
II, 236, *47*	Minnilus notatus	Pimephales notatus	Do.
II, 237, *47*	*Minnilus microstomus*	(?) Notropis blennius	Kentucky River.
II, 237, *47*	*Luxilus* or *Chrosomus erythrogaster.*	Chrosomus erythrogaster	Do.
II, 238, *48*	*Luxilus chrysocephalus*	Notropis cornutus	Ohio, Kentucky, Cumberland, and Green Rivers, etc.
II, 238, *48*	*Luxilus Kentuckiensis*	Hybopsis kentuckiensis	No stream mentioned.
II, 238, *49*	*Luxilus interruptus*	Notropis cornutus	Ohio River.
II, 239, *49*	*Semotilus dorsalis*	Semotilus atromaculatus	In the Kentucky and several other rivers.
II, 239, *49*	*Senotilus cephalus*	do	Creeks of Kentucky, etc.
II, 239, *50*	*Semotilus diplemia*	do	Kentucky River near Estill.
II, 240, *50*	*Rutilus plargyrus*	Notropis cornutus	Streams of Kentucky.
II, 241, *51*	*Rutilus Amblops*	Hybopsis amblops	Falls of the Ohio.
II, 241, *51*	*Rutilus melanurus*	Moxostoma aureolum	Ohio River.
II, 241, *52*	*Rutilus anomalous*	Campostoma anomalum	Licking River, etc.
II, 242, *52*	*Rutilus ruber*	Notropis umbratilis lythrurus.	Small streams which fall into the Elkhorn and Kentucky.
II, 299, *53*	*Pimephales promelas*	Pimephales promelas	Pond near Lexington. (Collector, Wm. M. Clifford.)
II, 300, *54*	*Catostomus anisurus*	Moxostoma anisurum	All over the Ohio and the larger streams as far as Pittsburgh.
II, 299 (i. e., 301), *55*	Catostomus bubalus	Ictiobus bubalus	Ohio River.
II, 301, *56*	*Catostomus carpio*	Carpiodes carpio	Falls of the Ohio.
II, 303, *56*	Catostomus velifer	Carpiodes velifer	Ohio River as far as Pittsburgh.
II, 303, *57*	*Catostomus xanthopus*	Hypentelium nigricans	Below the Falls of the Ohio.
II, 304, *57*	*Catostomus melanops*	Minytrema melanops	Falls of the Ohio.
II, 304, 58	*Catostomus melanotus*	Campostoma anomalum	Do.
II, 305, *59*	Catostomus erythrurus	Moxostoma aureolum	Ohio, Kentucky, Cumberland, and Tennessee Rivers, etc.
II, 305, *59*	*Catostomus flexuosus*	Catostomus commersonii	Most common species in Kentucky, in all the streams and ponds.
II, 306, *60*	Catostomus duquesni	Placopharynx duquesnii	Ohio River as far as Pittsburgh.
	Catostomus elongatas	Cycleptus elongatus	Do.
II, 355, *61*	*Cycleptus nigrescens*	do	Do.
II, 356, *62*	Pimelodus maculatus	Ictalurus punctatus	Do.
II, 357, *63*	Pivelodus cerulescens	do	Lower part of the Ohio River.
II, 357, *63*	Pimelodus pallidus	do	Channels or deeper parts of the Ohio River.
II, 358, *63*	Pimelodus pallidus var. Marginata.	do	Do.
II, 358, *64*	Pimelodus pallidus var. Lateralis.	do	Do.
II, 358, *64*	Pimelodus pallidus var. Leucoptera.	do	Do.
II, 358, *64*	Pimelodus argyrus	do	No stream mentioned.
II, 358, *64*	Pimelodus viscosus	Leptops olivaris	Falls of the Ohio.
II, 358, *64*	Pimelodus nebulosus	Ameiurus nebulosus	No stream mentioned.
II, 359, *65*	Pimelodus cupreus	Ameiurus natalis	Ohio River as far as Pittsburgh.
II, 359, *65*	Pimelodus lividus	do	No stream mentioned.
II, 360, *66*	Pimelodus melas	Ameiurus melas	Do.

Volume and page.	Species as recorded.	Present identification.	Locality.
II, 360, *66*	Pimelodus xanthocephalus	Ameiurus melas	Ohio and Kentucky Rivers, etc.
II, 360, *66*	Pimelodus limosus	Leptops olivaris	Muddy streams and near muddy banks of large rivers.
II, 362, *68*	Noturus flavus	Noturus flavus	Falls of the Ohio.
II, 362, *68*	Hypentelium macropterum	Catostomus nigricans	Do.
III, 165, *69*	Sarchirus vittatus	Lepisosteus osseus	Lower parts of the Ohio and at the Falls.
III, 166, *70*	Esox vittatus	Lucius lucius	Ohio River as far up as Pittsburgh.
III, 167, *71*	*Esox salmoneus*	Lucius ohiensis	Ohio River.
III, 168, *72*	Lepisosteus platostomus	Lepisosteus platostomus	Ohio, Tennessee, and Cumberland Rivers, etc.
III, 169, *73*	*Lepisosteus albus*	do.	Ohio River.
III, 169, *74*	*Lepisosteus oxyurus*	Lepisosteus osseus	Do.
III, 171, *74*	*Lepisosteus longirostris*	do.	Muskingum River.
III, 171, *75*	*Lepisosteus ferox*	Lepisosteus tristœchus	Lower parts of the Ohio.
III, 172, *76*	Litholepsis adamantinus	do.	Ohio River as far up as the Falls.
III, 245, *77*	*Anguilla laticauda*	Anguilla chrisypa	Ohio River.
III, 245, *78*	*Anguilla aterrima*	do.	Tennessee and Cumberland Rivers, etc.
III, 245, *78*	*Anguilla xanthomelas*	do.	Ohio River as far up as Pittsburgh.
III, 246, *78*	*Anguilla lutea*	do.	Cumberland, Green, and Licking Rivers, etc.
III, 247, *79*	Accipenser maculosus	Acipenser rubicundus	Ohio River as far up as Pittsburgh.
III, 247, *80*	Accipenser platorynchus	Scaphirhynchus platorynchus	Cumberland River and the Ohio as far up as Pittsburgh.
III, 248, *80*	*Accipenser serotimus*	Acipenser rubicundus	Ohio and Kentucky Rivers.
III, 248, *81*	*Accipenser ohiensis*	do.	Ohio River as far up as Pittsburgh.
III, 250, *82*	Polyodon folium	Polyodon spathula	Ohio River, etc. (Seen at the Falls in September, 1818.)
III, 251, *83*	Planirostra edentula	do.	Ohio River as far up as Pittsburgh.
III, 251, *84*	*Petromyzon nigrum*	Lampetra wilderi	Do.
85	*Pegedictis ictalops*	Cottus ictalops	Near Lexington, Ky.
85	*Etheostoma fontinalis*	Etheostoma flabellare	Springs and caves near Lexington, Ky.
86	*Semotilus (?) notatus*	Fundulus notatus	Cumberland River and Little River, a branch of it. (Collector, Mr. Wilkins.)
86	*Sarchirus (?) argenteus*	Lepisosteus osseus	Licking River, Slate Creek, etc. (Collector, Mr. Owings.)
86	*Accipenser lagenarius*	Acipenser rubicundus	Ohio River.

1832. C. S. Rafinesque.

Atlantic Journal and Friend of Knowledge, vol. 1, no. 1, Philadelphia, spring of 1832.

On page 20 of this publication, in article No. 15, entitled "Extracts from A Second Series of Zoological Letters written to Baron Cuvier of Paris, by Prof. Rafinesque in 1831," Rafinesque describes "a large and beautiful new catfish from the River Tennessee discovered in 1823," which he calls *Pimelodus lutescens.* The species is evidently the same as *Ictalurus punctatus* described by Rafinesque in 1818 from the Ohio.

1845. D. H. Storer.

Descriptions of species of fishes received, together with drawings, from Mr. Charles A. Hentz, of Florence, Ala. <Proc. Bost. Soc. Nat. Hist., vol. II, 1845, pp. 48, 49, 51.

In this short paper, read July 2 and 16, 1845, Dr. Storer gives descriptions of seven species of fishes, four of which were based on specimens collected by Mr. Hentz at Florence, Ala., presumably from the Tennessee River or its tributaries, as follows: *Leuciscus obesus* (=*Notropis cornutus*), *Etheostoma tessellata*, *Etheostoma cinerea*, and *Pœcilia olivacea* (=*Fundulus notatus*).

1846. David Humphreys Storer.

A Synopsis of the Fishes of North America. <Memoirs of the American Academy. Communicated to the meeting of the American Naturalists, at New Haven, April 3, 1845.

In this paper Dr. Storer recorded a few fishes from the Tennessee-Kentucky region chiefly on the authority of Rafinesque as follows:

Page.	Species as recorded.	Present identification.	Locality.
272	Etheostoma tessellata	Etheostoma tessellata	Florence, Ala. Caught in running water.
273	Etheostoma cinerea	Etheostoma cinereum	Florence, Ala. Caught in deep, still water, when fishing for perch.
292	Pomotis vulgaris	Eupomotis gibbosus	Common in the rivers, creeks, and ponds in Kentucky (Rafinesque).
294	Pomotis macrochira	Lepomis macrochirus	Tributaries of the Ohio (Rafinesque).
404	Pimelodus cupreus	Ameiurus natalis	Ohio River and its tributaries (Rafinesque).
404	Pimelodus limosus	Leptops olivaris	Ohio River (Rafinesque).
405	Pimelodus xanthocephalus	Ameiurus melas	Ohio River and tributaries (Rafinesque).
406	Noturus flavus	Noturus flavus	Ohio River (Rafinesque).
408	Leuciscus Americanus	Notropis cornutus	Do.
410	Leuciscus plargyrus	do	Kentucky (Rafinesque).
410	Leuciscus cephalus	Semotilus atromaculatus	Do.
410	Leuciscus Kentuckiensis	Hybopsis kentuckiensis	Do.
417	Leuciscus croceus	Rhinichthys atronacus croceus	Alabama.
417	Leuciscus prolixus	Campostoma anomalum	Do.
418	Leuciscus obesus	Notropis cornutus	Florence, Ala.
418	Pimephales promelas	Pimephales promelas	Kentucky; Ohio (Rafinesque).
424	Catostomus anisurus	Moxostoma anisurum	Ohio and most of its tributaries (Rafinesque).
424	Catostomus melanops	Minytrema melanops	Ohio River (Rafinesque).
424	Catosotmus bubalus	Ictiobus bubalus	Ohio and its tributaries (Rafinesque).
428	Exoglossum macropterum	Hypentelium nigricans	Ohio River (Rafinesque).
430	Pœcilia olivacea	Fundulus notatus	Florence, Ala.
430	Pœcilia catenata	Fundulus catenatus	Do.
436	Amblyopsis spelæus	Amblyopsis spelæus	Mammoth Cave, Ky. (De Kay).
466	Lepisosteus platostomus	Lepisosteus platostomus	Ohio River (Rafinesque).

1854. L. AGASSIZ.

Notice of a Collection of Fishes from the Southern Bend of the Tennessee River, Alabama. <Am. Jour. Sci. and Arts, vol. XVII, second series, 1854, pp. 297–308 (March), and 353–365 (May).

Speaking of the collection on which this paper was based, Prof. Agassiz said: "The only information we have at present upon the fishes of the Tennessee River has been published by Dr. D. H. Storer, who mentions nine species from the vicinity of Florence, Ala., in 'The Proceedings of the Boston Society of Natural History for 1845,' and of which short descriptions appeared in his 'Synopsis of the Fishes of North America,' in 1846. Having lately received a collection of not less than 33 species from the same water system brought together by the untiring efforts of Dr. Newman, of Huntsville, who has most kindly placed them in my hands for description, it seems desirable that an early notice of the general character of the ichthyological fauna of that region should be published, to serve as a standard of comparison with the fishes of the other western and southern rivers in the study of the geographic distribution." All the specimens were from Huntsville, Ala., presumably from the Tennessee River. The list follows:

Page.	Species as recorded.	Present identification.	Local name.
298	Pomoxis annularis	Pomoxis annularis	Speckled perch; white perch.
298	*Grystes nobilis*	Micropterus salmoides	Trout.
299	Ambloplites ichtheloides	Ambloplites rupestris	Goggle-eyed perch; black perch.
300	Calliurus punctulatus	Chænobryttus gulosus	Black perch; goggle-eye.
301	*Pomotis sanguinolentus*	Lepomis megalotis	Sun perch.
302	*Pomotis inscriptus*	do	
302	*Pomotis notatus*	Eupomotis heros	Pond perch.
302	Pomotis incisor	Lepomis pallidus	Do.
302	*Pomotis obscurus*	do	Do.
303	*Pomotis bombifrons*	Lepomis megalotis	
303	*Pomotis pallidus*	Eupomotis pallidus	
305	*Hyostoma Newmanii*	Diplesion blennioides	"Salmon."
307	*Amblodon concinnus*	Aplodinotus grunniens	Drum.
308	*Esox crassus*	Lucius reticulatus	Pike.
353	Hydrargyra catenata	Fundulus catenatus	
353	Zygonectes olivaceus	Fundulus notatus	
355	*Carpiodes Urus*	Ictiobus urus	
356	Catostomus communis	Catostomus commersonii	Fine-scaled sucker.
356	Catostomus nigricans	Hypentelium nigricans	Hog sucker.
356	Catostomus Duquesnii	Moxostoma aureolum	May sucker.
356	Catostomus melanops	Minytrema melanops	Do.
357	*Rhinichthys obtusus*	Rhinichthys atronasus	Minnow.
357	Chondrostoma prolixum	Campostoma anomalum	Do.
358	*Hybopsis gracilis*	Hybopsis amblops	
359	Chrosomus erythrogaster	Chrosomus erythrogaster	
359	Stilbe obesus	Notropis cornutus	Hickory shad; gizzard shad.
359	Hypsolepis gibbosus	Notropis cornutus (?)	Silversides.
359	Leuciscus croceus	Rhinichthys atronasus croceus	
360	Lepidosteus platostomus	Lepisosteus platostomus	Gar.
361	Amia calva	Amia calva	Scaly cat; carp. Found in mill ponds.
361	Pimelodus cærulescens	Ictalurus punctatus	Channel cat.
361	Pimelodus Catus	Ameiurus natalis	Mud cat.
361	Acipenser rubricundus	Acipenser rubricundus	Sturgeon.
361	Acipenser maculosus	do	Do.

1867. E. D. Cope.

Description of a new genus of Cyprinoid Fishes from Virginia. <Proc. Acad. Nat. Sci. Phila., 1867, pp. 95–97.

This paper contains a description of *Phenacobius uranops* from the Holston River near Saltville, Va.

1867a. E. D. Cope.

On the Genera of Fresh-water Fishes *Hypsilepis* Baird and *Photogenis* Cope, their Species and Distribution. <Proc. Acad. Nat. Sci. Phila., 1867, pp. 156–166.

In this paper Prof. Cope records the following species from the Tennessee and Cumberland River Basins:

Page.	Species as recorded.	Present identification.	Locality.
158	Hypsilepis cornutus	Notropis cornutus	Tennessee River.
159	Hypsilepis cornutus frontalis	do	Holston River.
160	*Hypsilepis coccogenis*	Notropis coccogenis	"It occurs in abundance in the clear and often rapid creeks that flow into the North and Middle Forks of the Holston River in Virginia."
160	*Hypsilepis galacturus*	Notropis galacturus	"Abundant in the tributaries of the Holston River in Virginia."
165	*Photogenis leuciodus*	Notropis leuciodus	Tributaries of the Holston.
165	*Photogenis telescopus*	Notropis telescopus	"All the rapid streams tributary to the Holston River in Virginia."

1869. E. D. Cope.

On the Distribution of Fresh-water Fishes in the Alleghany Region of Southwestern Virginia. <Jour. Acad. Nat. Sci. Phila., vol. VI, sec. ser., pt. 3, Jan., 1869, pp. 207–247.

The collections on which this paper was based were made by Prof. Cope in July to October, 1867, during which period he resided in the region of the headwaters of the James, Roanoke, Kanawha, and Tennessee Rivers. A considerable portion of October was spent at Saltville, Smyth County, Va., with his friend William Alex. Stuart, at that time one of the proprietors of the salt wells and furnaces at that place and who materially assisted Prof. Cope in making the collections.

From Saltville as headquarters visits were made to the North and Middle Forks of the Holston and most of the nearby tributaries, including Bear, Hungrysmother, and Chilhowie Creeks.

Only the species recorded by Prof. Cope from the Tennessee Basin are included in the following tables:

Page.	Species as recorded.	Present identification.	Locality.
211	*Cottogaster aurantiacus*	Hyposomus aurantiacus	Holston River, Va.
211	Percina caprodes	Percina caprodes	North Fork Holston River, Saltville, Va.
212	*Pœcilichthys zonalis*	Etheostoma zonale	Do.
213	Pœcilichthys flabellatus	Etheostoma flabellare	Do.
214	Boleosoma olmstedi	Boleosoma nigrum olmstedi	Do.
215	*Hyostoma blennioperca*	Diplesion blennioides	Do.
215	*Hyostoma simoterum*	Ulocentra simotera	Do.
216	Micropterus fasciatus	Micropterus dolomieu	Do.
217	Ambloplites rupestris	Ambloplites rupestris	Do.
225	Lepomis inscriptus	Lepomis megalotis	Do.
225	Uranidea carolinæ	Cottus ictalops	Cold spring creeks of the southern Allegheny region.
226	*Ceratichthys hyalinus*	Hybopsis amblops	North Fork Holston River, Saltville, Va.
226	Ceratichthys biguttatus	Hybopsis kentuckiensis	Do.
227	*Ceratichthys monacus*	Hybopsis monacus	Do.
228	Rhinichthys lunatus	Rhinichthys atronasus	Do.
228	Phenacobius uranops	Phenacobius uranops	Do.
229	Hypsilepis cornutus frontalis	Notropis cornutus frontalis	Do.
229	Hypsilepis coccogenis	Notropis coccogenis	Do.
229	Hypsilepis galacturus	Notropis galacturus	Do.
229	Photogenis telescopus	Notropis telescopus	Do.
229	Photogenis leuciodus	Notropis leuciodus	Do.
231	*Hybopsis spectrunculus*	Notropis spectrunculus	Bear Creek, Smyth County, Va., and probably Hungrysmother and Chilhowie Creeks, adjacent tributaries of Middle Fork of Holston River.
231	*Hybopsis rubricroceus*	Notropis rubricroceus	Bear Creek, Smyth County, Va., and probably Hungrysmother and Chilhowie Creeks, adjacent tributaries of Middle Fork of Holston River, and in Tumbling Creek, tributary to North Fork of Holston River.
232	*Hybopsis lacertosus*	Notropis lacertosus	Bear Creek, tributary to Middle Fork of Holston River.
233	*Alburnellus micropteryx*	Notropis micropteryx	Holston River.
235	Campostoma anomalum	Campostoma anomalum	Tributaries of the Holston.
236	Teretulus duquesnei	Moxostoma aureolum	Holston River.
236	Catostomus nigricans	Hypentelium nigricans	Do.
236	Catostomus communis	Catostomus commersonii	Do.
238	Fundulus catenatus	Fundulus catenatus	Tributaries of the Holston.
238	Salmo fontinalis	Salvelinus fontinalis	Do.
238	Lepidosteus huronensis	Lepisosteus osseus	Holston River at Saltville.
239	Petromyzon sp (?)	Ichthyomyzon concolor	Upper waters of Holston River.

1870. E. D. COPE.

On some Etheostomine Perch from Tennessee and North Carolina. <Proc. Am. Philos. Soc. Phila., vol. XI, 1870 (Jan. 7), pp. 261–270.

In this paper Prof. Cope recorded the following species from the Tennessee and Cumberland Rivers:

Page.	Species as recorded.	Present identification.	Locality.
262	Etheostoma blennioides	Diplesion blennioides	Headwaters of the Cumberland River, Campbell County, Tenn.
262	Cottogaster aurantiacus	Hypohomus aurantiacus	French Broad River, Madison County, N. C.
262	Percina caprodes	Percina caprodes	South Fork of the Cumberland River, Campbell County, Tenn.
263	Pœcilichthys zonalis	Etheostoma zonale	Tributary of the French Broad River, Madison County, N. C.
264	*Pœcilichthys sanguifluus*	Etheostoma maculatum	Headwaters South Fork of Cumberland River in Tennessee.
265	*Pœcilichthys camurus*	Etheostoma camurum	Headwaters of the Cumberland River in Tennessee.
266	*Pœcilichthys vulneratus*	Etheostoma vulneratum	Warm Springs Creek, tributary of the French Broad River, Madison County, N. C.
267	*Pœcilichthys rufilineatus*	Etheostoma rufilineatum	Do.
268	Pœcilichthys cœruleus	Etheostoma cœruleum	South Fork of the Cumberland River, Tenn.
270	Hyostoma cymatogrammum	Diplesion blennioides(?)	Head of the Cumberland River, Tenn., also French Broad River, N. C.
270	Hyostoma simoterum	Ulocentra simoterum	Tributary of Clinch River, Tenn.

1870. AUG. DUMÉRIL.

Hist. Nat. des Poiss. ou Ichth. Gen., t. second, Ganoides, Dipnés, Lophobranches, pp. 1–624, 1870.

Only three species from the Ohio Basin are mentioned in this work.

Page.	Species as recorded.	Present identification.	Locality.
124	*Acipenser (Huso) paranasimos*	Acipenser rubicundus	Huntsville, Ala.
143	*Acipenser (Huso) Rafinesquii*	do	Ohio River.
229	*Acipenser (Antaceus) Cincinnati*	do	Ohio River at Cincinnati.

1872. F. W. PUTNAM.

The Blind Fishes of Mammoth Cave and their allies. <American Naturalist, vol. VI, no. 1, January, 1872, pp. 6–30, pls. 1, 2.

In this article Prof. Putnam states that Prof. Cope obtained specimens of *Amblyopsis spelæus* from Wyandotte Cave and from wells in its vicinity, that there is in the Museum of Comparative Zoology a specimen labeled "from a well near Lost River, Orange County, Ind.," and that he has examined a number of specimens from Mammoth Cave. He also refers to the type specimen of *Typhlichthys subterraneus* which was obtained by J. E. Younglove, Esq., "from a well near Bowling Green, Ky.," and further states that he has examined of this species seven specimens collected in Mammoth Cave by Mr. Alpheus Hyatt in September, 1859; one from Moulton, Lawrence County, Ala., presented by Mr. Thomas Peters; and one from Lebanon, Wilson County, Tenn., presented by Mr. J. M. Safford. This paper also contains the original description of *Chologaster agassizii*, based on a specimen from a well in Lebanon, Tenn. Moulton is in the Tennessee Basin, while Lebanon is in the Cumberland Basin.

1876. DAVID STARR JORDAN.

Manual of the Vertebrates of the Northern United States, Including the District East of the Mississippi River, and North of North Carolina and Tennessee, Exclusive of Marine Species. By David Starr Jordan, M. S., M. D., professor of Natural History in Northwestern Christian University and in Indiana State Medical College. Chicago: Jansen, McClurg & Co. 1876, pp. 1–342.

In this volume the following species are mentioned from specific streams in the region covered by the present paper:

Page.	Species as recorded.	Present identification.	Locality.
224	Diplesium blennioides	Diplesion blennioides	Holston River.
225	Stizostedium salmoneum	Stizostedion vitreum	Ohio River.
236	Ichthelis incisor obscurus	Lepomis pallidus	Tennessee River.
237	Ichthelis bombifrons	Lepomis megalotis	Do.
240	Pomotis notatus	Eupomotis heros	Headwaters of Tennessee River.
240	Pomotis pallidus	Eupomotis pallidus	Tennessee River.
242	Haploidonotus concinnus	Aplodinotus grunniens	Do.
252	Zygonectes catenatus	Fundulus catenatus	Do.
257	Amblyopsis spelæus	Amblyopsis spelæus	Subterranean streams of Kentucky, Indiana, Mammoth Cave, Wyandotte Cave, etc.
257	Typhlichthys subterraneus	Typhlichthys subterraneus	Subterranean streams in Kentucky, Tennessee, and Alabama.
257	Chologaster agassizii	Chologaster agassizii	Subterranean streams in Tennessee and Kentucky.
260	Salmo fontinalis	Salvelinus fontinalis	French Broad River.
266	Pomolobus chrysochloris	Pomolobus chrysochloris	Ohio River.
266	Dorosoma notatum	Dorosoma cepedianum	Do.
280	Ceratichthys monachus	Hybopsis monacus	Holston River.
281	Phenacobius uranops	Phenacobius uranops	Do.
282	Hybopsis spectrunculus	Notropis spectrunculus	Do.
283	Hybopsis rubricroceus	Notropis rubricroceus	Upper Tennessee River.
283	Hemitremia vittata	Leuciscus flammeus	Headwaters of Tennessee and Cumberland Rivers.
286	Lythrurus ardens	Notropis umbratilis ardens	Cumberland River.
287	Luxilus coccogenis	Notropis coccogenis	Headwaters of Tennessee River.
288	Photogenis telescopus	Notropis telescopus	Holston River.
289	Photogenis leuciodus	Notropis leuciodus	Do.
290	Minnilus micropteryx	Notropis micropteryx	Clinch River.
297	Carpiodes velifer	Carpiodes velifer	Ohio River.

1877. DAVID STARR JORDAN.

A Partial Synopsis of the Fishes of Upper Georgia; with supplementary papers on Fishes of Tennessee, Kentucky, and Indiana, by David Starr Jordan, M. D., Ph. D., professor of natural history in Butler University, Indianapolis, Ind. <Ann. N. Y. Lyc. Nat. Hist., vol. XI, 1877 (June), pp. 307–377.

As Dr. Jordan stated in the introduction, "The material on which the present paper is based was obtained by the writer and his assistant, Mr. Charles H. Gilbert, during the past summer (1876), in a month's residence and constant field work at Rome, Ga.; a week's seining in the South Fork of the Ocmulgee River at Flat Rock, Dekalb County, Ga.; and a day's work in tributaries of the Chattahoochee River near Atlanta. * * *. A visit to Powells River and other tributaries of Clinch River near Cumberland Gap, Tenn., and to the French Broad and Big Pigeon Rivers near Newport, Tenn., enabled us to make considerable collections." A few species were collected in Rockcastle River and tributaries, in Rockcastle and Laurel Counties, in southeast Kentucky.

The following species were listed, all on page 370, from "Powells River and other tributaries of Clinch River near Cumberland Gap and French Broad and Big Pigeon Rivers near Newport, Tenn.":

Species as recorded.	Present identification.
Alvordius aspro	Hadropterus aspro.
Diplesium simoterum	Hadropterus simotera.
Micropterus salmoides	Micropterus salmoides.
Ambloplites rupestris	Ambloplites rupestris.
Haploidonotus grunniens	Aplodinotus grunniens.
Potamocottus sp. (carolinæ?)	Cottus ictalops.
Xenisma catenata	Fundulus catenatus.
Campostoma anomalum prolixum	Campostoma anomalum.
Nocomis biguttatus	Hybopsis kentuckiensis.
Nocomis amblops	Hybopsis amblops.
Phenacobius uranops	Phenacobius uranops.
Luxilus cornutus	Notropis cornutus.
Luxilus coccogenis	Notropis coccogenis.
Luxilus galacturus	Notropis galacturus.
Nototropis photogenis	Notropis photogenis.
Nototropis dinemus	Notropis atherinoides.
Catostomus teres	Catostomus commersonii.
Catostomus nigricans	Hypentelium nigricans.
Erimyzon oblongus	Erimyzon sucetta.
Maxostoma duquesnei	Moxostoma aureolum.
Ichthælurus punctatus	Ictalurus punctatus.
Pelodichthys olivaris	Leptops olivaris.
Noturus eleutherus	Schilbeodes eleutherus.

The following species were listed on page 373 from Rockcastle River and tributaries in Rockcastle and Laurel Counties, Ky.:

Species as recorded.	Present identification.
Ethostoma flabellare	Etheostoma flabellare.
Boleosoma maculatum	Boleosoma nigrum.
Diplesium simoterum	Ulocentra simotera.
Alvordius aspro	Hadropterus aspro.
Percina caprodes	Percina caprodes.

Species as recorded.	Present identification.
Micropterus salmoides	Micropterus salmoides.
Micropterus pallidus	Do.
Ambloplites rupestris	Ambloplites rupestris.
Xenotis megalotis	
Campostoma anomalum	Campostoma anomalum.
Hyborhynchus notatus	Pimephales notatus.
Semotilus corporalis	Semotilus atromaculatus.
Nocomis biguttatus	Hybopsis kentuckiensis.
Phenacobius uranops	Phenacobius uranops.
Chrosomus erythrogaster	Chrosomus erythrogaster.
Luxilus cornutus	Notropis cornutus.
Luxilus galacturus	Notropis galacturus.
Lythrurus ardens	Notropis umbratilis lythrurus.
Hemitremia vittata	Leuciscus flammeus.
Nototropis dinemus	Notropis atherinoides.
Nototropis micropteryx	Notropis micropteryx.
Catostomus teres	Catostomus commersonii.
Catostomus nigricans	Hypentelium nigricans.
Erimyzon oblongus	Erimyzon sucetta.
Myxostoma duquesnii	Moxostoma aureolum.
Anguilla vulgaris	Anguilla chrisypa.
Pelodichthys sp. (nov.?)	Leptops olivaris.

1877a. DAVID S. JORDAN.

Notes on *Cottidæ*, *Etheostomatidæ*, *Percidæ*, *Centrarchidæ*, *Aphododeridæ*, *Umbridæ*, *Esocidæ*, *Dorysomatidæ*, *Cyprinidæ*, *Catostomidæ*, and *Hyodontidæ*, with revisions of the genera and descriptions of new or little known species. <Bull. U. S. Nat. Mus., no. 10, pp. 5–120, pls. 1–45, 1877.

In this paper the following species are recorded from the Tennessee and Cumberland Basins:

Page.	Species as recorded.	Present identification.	Locality.
10, 15	*Arlina atripinnis*	Ulocentra simotera	Tributary of Cumberland River near Nashville; collector, Prof. A. Winchell.
11	*Etheostoma squamiceps*	Etheostoma squamiceps	Russellville, Ky.; collector, Dr. Bebb.
15	Diplesium newmani	Diplesion blennioides	Tennessee River.
15	Diplesium simoterum	Ulocentra simotera	Cumberland and upper Tennessee Rivers.
16	Nothonotus sanguifluus	Etheostoma maculatum	Cumberland River.
17	Etheostoma tessellata	Etheostoma tessellatum	Florence, Ala.
17	Etheostoma cinerea	Etheostoma cinereum	Do.
21	Eupomotis pallidus	Eupomotis pallidus	Tennessee River.
23	Xenotis sanguinolentus	Lepomis megalotis	Do.
35	Lepiopomus bombifrons	do	Do.
35	Xystroplites notatus	Eupomotis heros	Do.
42	Xenotis inscriptus	Lepomis megalotis	Do.
67	*Hyodon selenops*	Hiodon selenops	Tennessee River at Chattanooga and Cumberland River.
101	Noturus eleutherus	Schilbeodes eleutherus	French Broad River, Tenn.

1877. DAVID S. JORDAN and A. W. BRAYTON.

On *Lagochila*, a new genus of Catostomoid Fishes. <Proc. Acad. Nat. Sci. Phila., vol. 29, 1877, pp. 280–283.

This paper contains the original description of the genus *Lagochila* and its single species, *Lagochila lacera*, based on two specimens obtained by the writers in the summer of 1877 in Chickamauga Creek near Ringgold, Ga., and one in Elk River at Estill Springs, Tenn.

1878. **David S. Jordan** and **Alembert W. Brayton.**
On the Distribution of the Fishes of the Alleghany Region of South Carolina, Georgia, and Tennessee, with Descriptions of New or Little Known Species. <Bull. U. S. Nat. Mus., no. 12, pp. 1–96, 1878.

This paper was based primarily on field work done and collections made by Drs. Jordan and Brayton, assisted by Charles H. Gilbert and a party of students from Butler University, during the summer of 1877, in various streams of South Carolina, Georgia, and Tennessee.

Collections were made in the Tennessee Basin in the following streams: Clinch River and tributaries in southwestern Virginia; Powell's River, Indian Creek, and Station Creek near Cumberland Gap; Holston River and various tributaries in southwestern Virginia; French Broad River at Newport, Tenn.; Big Pigeon River at Cliffton, Wayne County, Tenn.; Swannanoa River at foot of Black Mountain, N. C.; Chickamauga Creek at Ringgold, Ga.; and Elk River and tributaries at Estill Springs, Franklin County, Tenn.

Collections were made in the Cumberland Basin in the following streams: Round-Stone River in Rockcastle County, Ky.; Rockcastle River near Livingston, Ky.; Big Laurel River in Laurel County, Ky.; Cumberland River about Pineville, Ky.; Yellow Creek near Cumberland Gap; Stone River near Murfreesboro, Tenn.

COLLECTIONS MADE IN VARIOUS STREAMS OF TENNESSEE AND CUMBERLAND BASINS.

TENNESSEE BASIN.

Page.	Species as recorded.	Present identification.	Locality.
57	Potamocottus meridionalis	Cottus ictalops	Chickamauga River; Cave Spring at Cumberland Gap; Holston River; French Broad River.
57	Percina caprodes	Percina caprodes	Generally abundant in clear streams.
58	Alvordius maculatus	Hadropterus aspro	Clinch River; French Broad River; Chickamauga Creek.
58	Hadropterus aurantiacus	Hypohomus aurantiacus	French Broad River (Cope).
58	Diplesium blennioides	Diplesion blennioides	Holston River; French Broad River; Chickamauga Creek.
58	Diplesium simoterum	Ulocentra simotera	Clinch River; Holston River.
58	Boleosoma maculatum	Boleosoma nigrum	Holston River.
58	Nothonotus zonalis	Etheostoma zonale	Holston and French Broad Rivers (Cope).
58	Nothonotus vulneratus	Etheostoma vulneratum	French Broad River at Warm Springs (Cope).
58	Nothonotus rufilineatus	Etheostoma rufilineatum	French Broad River (Cope).
59	Pœcilichthys jessiæ	Etheostoma jessiæ	Chickamauga Creek at Ringgold, Ga.
59	Etheostoma flabellare	Etheostoma flabellare	Upper Tennessee in clear rapid streams.
59	(Etheostoma) cinerea	Etheostoma cinereum	Florence, Ala. (Storer).
59	(Etheostoma) tessellata	Etheostoma tessellatum	Tennessee River at Florence, Ala. (Storer).
60	Micropterus pallidus	Micropterus salmoides	Tennessee Basin.
60	Stizostethium vitreum	Stizostedion vitreum	French Broad River (Cope).
60	Stizostethium salmoneum	do	Do.
60	Micropterus salmoides	Micropterus salmoides	Tennessee River.
60	Ambloplites rupestris	Ambloplites rupestris	Tennessee Basin.
60	Chænobryttus gulosus	Chænobryttus gulosus	Lower Tennessee River.
60	Lepiopomus pallidus	Lepomis pallidus	Tennessee Basin.
60	Lepiopomus obscurus	do	Huntsville, Ala. (Agassiz).
60	(Lepiopomus) bombifrons	Lepomis megalotis	Do.
61	Xenotis sanguinolentus	do	Tennessee River at Huntsville (Agassiz).
61	Xenotis inscriptus	do	Tennessee River at Huntsville (Agassiz); also upper waters of the Tennessee (Cope).
61	Eupomotis pallidus	Eupomotis pallidus	Huntsville, Ala. (Agassiz).
61	Xystroplites notatus	Eupomotis heros	Huntsville (Agassiz); upper waters of the Tennessee (Cope).
61	Haploidonotus grunniens	Aplodinotus grunniens	Tennessee Basin.
61	Labidesthes sicculus	Labidesthes sicculus	Coal Creek, a tributary of Clinch River (Cope).
62	Xenisma catenatum	Fundulus catenatus	Elk River; Clinch River; Holston River; Florence, Ala. (Storer).
62	Zygonectes notatus	Fundulus notatus	Florence, Ala. (Storer).
62	Hyodon selenops	Hiodon selenops	Tennessee River at Chattanooga.
62	Pomolobus chrysochloris	Pomolobus chrysochloris	Lower Tennessee.
63	Dorosoma cepedianum	Dorosoma cepedianum	Do.
63	Salvelinus fontinalis	Salvelinus fontinalis	Swannanoa River and all clear tributaries of the French Broad in western North Carolina; certain tributaries of the Holston in southwestern Virginia; headwaters of the Little Tennessee in Rabun County, Ga.

TENNESSEE BASIN—Continued.

Page.	Species as recorded.	Present identification.	Locality.
63	Campostoma anomalum var. prolixum.	Campostoma anomalum	Abundant everywhere in clear pools of Swannanoa River and elsewhere in basins of the Tennessee and Cumberland.
63	Hyborhynchus notatus	Pimephales notatus	Chickamauga Creek.
64	Hydrophlox rubricroceus	Notropis rubricroceus	Tributaries of the Holston (Cope).
64	Hydrophlox lacertosus	Notropis lacertosus	Holston River (Cope).
64	Alburnops microstomus	Notropis microstomus	Holston River (Cope). (?)
64	Luxilus cornutus	Notropis cornutus	Abundant in every stream examined.
64	Luxilus coccogenis	Notropis coccogenis	Do.
64	Photogenis galacturus	Notropis galacturus	Do.
64	Notropis atherinoides	Notropis atherinoides	Tributaries of Clinch River.
65	Notropis micropteryx	Notropis micropteryx	Tributaries of Clinch and Holston.
65	Notropis photogenis	Notropis photogenis	French Broad River.
65	Notropis telescopus	Notropis telescopus	Elk River.
65	Notropis lirus	Notropis lirus	Elk River; Chickamauga Creek.
65	Phoxinus flammeus	Leuciscus flammeus	Elk River.
66	Gila estor	Leuciscus vandoisulus	Elk River; Stone River.
67	Notemigonus chrysoleucus	Abramis crysoleucas	Tennessee Basin.
67	Phenacobius uranops	Phenacobius uranops	Elk River; Chickamauga Creek; French Broad River.
67	Rhinichthys obtusus	Rhinichthys atronasus croceus	Tennessee Basin.
67	Ceratichthys monachus	Hybopsis monacus	Chickamauga Creek.
67	Ceratichthys dissimilis	Hybopsis dissimilis	Elk River.
68	Ceratichthys winchelli	Hybopsis amblops	Tennessee River.
68	Ceratichthys biguttatus	Hybopsis kentuckiensis	Tributaries of the French Broad and the Clinch.
68	Quassilabia lacera	Lagochila lacera	Chickamauga Creek; Elk River.
68	Myxostoma macrolepidotum duquesnei.	Moxostoma aureolum	Holston, Clinch, and French Broad Rivers, and Chickamauga Creek.
69	Placopharynx carinatus	Placopharynx duquesnii	French Broad River.
69	Erimyzon sucetta	Erimyzon sucetta	Clinch River.
69	Catostomus nigricans	Hypentelium nigricans	Tennessee River.
69	Catostomus commersoni	Catostomus commersonii	Tennessee and Cumberland Basins.
69	Ichthælurus punctatus	Ictalurus punctatus	Tennessee River.
70	Amiurus natalis var. cupreus	Ameiurus natalis	Do.
70	Pelodichthys olivaris	Leptops olivaris	French Broad River.
70	Noturus eleutherus	Schilbeodes eleutherus	Big Pigeon River.
70	Anguilla vulgaris	Anguilla chrisypa	Tennessee River.
71	Lepidosteus osseus	Lepisosteus osseus	Tennessee and Cumberland Rivers.
71	Polyodon folium	Polyodon spathula	Do.

CUMBERLAND BASIN.

73	Potamocottus meridionalis	Cottus ictalops	Cumberland River at Nashville.
73	Percina caprodes	Percina caprodes	Cumberland River.
73	Alvordius maculatus	Hadropterus aspro	Cumberland and Rockcastle Rivers at various points.
73	Alvordius phoxocephalus	Hadropterus phoxocephalus	Cumberland River at Nashville.
73	Diplesium blennioides	Diplesion blennioides	Cumberland and Stone Rivers.
73	Diplesium simoterum	Ulocentra simotera	Rockcastle River.
75	Boleosoma maculatum	Boleosoma nigrum	Do.
75	Etheostoma flabellare	Etheostoma flabellare	Mountain tributaries of the Cumberland.
75	Stizostethium salmoneum	Stizostedion vitreum	Rockcastle River.
75	Micropterus pallidus	Micropterus dolomieu	Lower Cumberland River.
75	Micropterus salmoides	Micropterus salmoides	Do.
75	Ambloplites rupestris	Ambloplites rupestris	Cumberland River and tributaries.
76	Apomotis cyanellus	Apomotis cyanellus	Cumberland River at Nashville.
76	Lepiopomus pallidus	Lepomis pallidus	Cumberland River.
76	Lepiopomus obscurus	do	Cumberland River near Nashville.
76	Xenotis megalotis	Lepomis megalotis	Cumberland River.
76	Pomoxys nigromaculatus	Pomoxis sparoides	Cumberland River at Nashville.
76	Pomoxys annularis	Pomoxis annularis	Do.
76	Haploidonotus grunniens	Aplodinotus grunniens	Cumberland River.
76	Labidesthes sicculus	Labidesthes sicculus	Stone River at Murfreesboro.
77	Xenisma catenatum	Fundulus catenatus	Streams about Nashville.
77	Zygonectes notatus	Fundulus notatus	Cumberland and Stone Rivers.
77	Hyodon selenops	Hiodon selenops	Cumberland River.
77	Pomolobus chrysochloris	Pomolobus chrysochloris	Lower Cumberland.
77	Dorosom cepedianum heteraurum.	Dorosoma cepedianum	Do.
77	Campostoma anomalum	Campostoma anomalum	Cumberland River and tributaries.
78	Pimephales promelas	Pimephales promelas	Tributaries of the Cumberland near Nashville.
78	Hyborhynchus notatus	Pimephales notatus	Cumberland River everywhere.
78	Luxilus cornutus	Notropis cornutus	Do.
78	Photogenis galacturus	Notropis galacturus	Do.
78	Photogenis analostanus	Notropis whipplii	Cumberland River at Nashville.
78	Lythrurus ardens	Notropis umbratilis lythrurus	Cumberland River everywhere.
78	Notropis atherinoides	Notropis atherinoides	Rockcastle River and other upper tributaries of the Cumberland.

CUMBERLAND BASIN—Continued.

Page.	Species as recorded.	Present identification.	Locality.
79	Notropis micropteryx	Notropis micropteryx	Rockcastle River.
79	Notropis telescopus	Notropis telescopus	Stone River at Murfreesboro.
79	Hemitremia vittata	Leuciscus flammeus	Big Laurel River.
79	Gila estor	Leuciscus vandoisulus	Stone River at Murfreesboro.
79	Chrosomus erythrogaster	Chrosomus erythrogaster	Tributaries of Rockcastle River.
79	Notemigonus chrysoleucus	Abramis crysoleucas	Cumberland Basin in sluggish waters.
79	Phenacobius uranops	Phenacobius uranops	Rockcastle River.
79	Ceratichthys dissimilis	Hybopsis dissimilis	Cumberland River at Nashville.
79	Ceratichthys amblops	Hybopsis amblops	Do.
79	Ceratichthys biguttatus	Hybopsis kentuckiensis	Cumberland River everywhere.
80	Semotilus corporalis	Semotilus atromaculatus	Rockcastle River.
80	Myxostoma macrolepidotum duquesnei.	Moxostoma aureolum	Cumberland River.
80	Erimyzon sucetta	Erimyzon sucetta	Rockcastle River and Cumberland River at Nashville.
80	Minytrema melanops	Minytrema melanops	Cumberland River at Nashville.
80	Catostomus nigricans	Hypentelium nigricans	Cumberland River.
80	Catostomus commersoni	Catostomus commersonii	Do.
80	Cycleptus elongatus	Cycleptus elongatus	Cumberland River at Nashville.
80	Carpiodes cutisanserinus	Carpiodes difformis	Do.
81	Ichthælurus punctatus	Ictalurus punctatus	Cumberland River.
81	Amiurus natalis	Ameiurus natalis	Cumberland River at Nashville.
81	Amiurus nigricans	Ameiurus lacustris	Falls of the Cumberland.
81	Pelodichthys olivaris	Leptops olivaris	Rockcastle River at Livingston and Cumberland River below the falls.
81	Anguilla vulgaris	Anguilla chrisypa	Cumberland River and Rockcastle River at mouth of Round Stone River.
81	Lepidosteus osseus	Lepisosteus osseus	Cumberland River at Nashville.
81	Polyodon folium	Polyodon spathula	Cumberland River.

1878. DAVID STARR JORDAN.

Manual of the Vertebrates of the Northern United States, Including the District East of the Mississippi River and North of North Carolina and Tennessee, Exclusive of Marine Species, second edition. Chicago, Jansen, McClurg & Co., 1878, pp. 1–407.

In this volume the following species are recorded from Kentucky and Tennessee:

Diplesium simoterum, Tennessee and Cumberland Rivers; *Ulocentra atripinnis*, Cumberland River; *Nothonotus vulneratus*, French Broad River; *Nothonotus rufilineatus*, French Broad River; *Pœcilichthys jessiæ* Jordan and Brayton, new species, Tennessee River (Chickamauga Creek at Ringgold, Ga.); *Lepiopomus bombifrons*, Tennessee River; *Lepiopomus obscurus*, Cumberland and Tennessee Rivers; *Amblyopsis spelæus*, subterranean streams of Kentucky and Indiana, Mammoth Cave, etc.; *Typhlichthys subterraneus*, subterranean streams of Kentucky, Tennessee, and Alabama; *Chologaster agassizi*, subterranean streams in Tennessee and Kentucky; *Hyodon selanops*, Cumberland River; *Hybopsis lacertosus*, Tennessee River; *Hybopsis rubricroceus*, Tennessee River; *Luxilus coccogenis*, Tennessee River; *Luxilus galacturus*, Cumberland River; *Lythrurus ardens*, Cumberland River; *Notropis micropteryx*, Tennessee and Cumberland Rivers; *Notropis telescopus*, Tennessee River; *Cliola leucioda*, Tennessee River; *Phenacobius uranops*, Tennessee River; *Gila estor*, Cumberland and Tennessee Rivers; *Phoxinus flammeus* Jordan and Gilbert, new species, Elk River, Tennessee; *Hemitremia vittata*, Tennessee and Cumberland Rivers; *Ceratichthys monachus*, Tennessee River; *Noturus eleutherus*, French Broad River.

1878a. DAVID S. JORDAN.

A Synopsis of the Family Catostomidæ. Bull. U. S. Nat. Mus., no. 12, pp. 97–230, 1878.

In this paper are a few references to species from Tennessee and Kentucky, as follows:

Quassilabia lacera (=*Lagochila lacera*), two specimens from Chickamauga Creek at Ringgold, Ga., and one from Elk River near Estill Springs, Tenn.; *Placopharynx carinatus* (=*Placopharynx duquesnii*), numerous specimens from the French Broad River at Wolf Creek and other localities in North Carolina; *Myxostoma macrolepidotum duquesnii* (=*Moxostoma aureolum*), Cumberland River, Tenn.; *Myxostoma velatum* (=*Moxostoma anisurum*), Chickamauga Creek and Clinch River; *Erimyzon sucetta*, Cumberland River; *Carpiodes cutisanserinus* (=*Carpiodes difformis*), Cumberland River.

1883. DAVID S. JORDAN and JOSEPH SWAIN.

List of Fishes Collected in the Clear Fork of the Cumberland, Whitley County, Ky., with descriptions of three new species. <Proc. U. S. Nat. Mus., vol. VI, 1883 (Nov. 27), pp. 248–251.

In May, 1883, Profs. Jordan and Swain, aided by a party of students from Indiana University, made a small collection of fishes from the Clear Fork of the Cumberland River and in its tributaries, Wolf Creek and Briar Creek, near Pleasant View, Whitley County, Ky.

The collection contained 23 species, of which 3 were described as new.

Page.	Species as recorded.	Present identification.	Locality.
248	Amiurus natalis	Ameiurus natalis	Clear Fork of the Cumberland.
248	Catostomus teres	Catostomus commersonii	Do.
248	Catostomus nigricans	Hypentelium nigricans	Do.
248	Moxostoma velatum	Moxostoma anisurum	Do.
248	Moxostoma macrolepidotum duquesnei.	Moxostoma aureolum	Do.
248	Campostoma anomalum	Campostoma anomalum	Do.
248	Chrosomus erythrogaster	Chrosomus erythrogaster	Do.
248	Hyborhynchus notatus	Pimephales notatus	Do.
248	Ericymba buccata	Ericymba buccata	Do.
249	Minnilus diplæmius	Notropis umbratilis lythrurus.	Do.
249	Minnilus cornutus	Notropis cornutus	Do.
249	Hemitremia vittata	Leuciscus flammeus	Clear Fork of the Cumberland and Wolf Creek.
249	Rhinichthys obtusus	Rhinichthys atronasus	Clear Fork of the Cumberland.
249	Ambloplites rupestris	Ambloplites rupestris	Do.
249	Lepomis megalotis	Lepomis megalotis	Do.
249	Lepomis machrochirus	Lepomis machrochirus	Do.
249	Lepomis cyanellus	Apomotis cyanellus	Do.
249	Micropterus dolomieu	Micropterus dolomieu	Do.
249	Alvordius aspro	Hadropterus aspro	Do.
249	Diplesium blennioides	Diplesion blennioides	Do.
249	*Boleosoma susanæ*	Boleosoma susanæ	Wolf Creek and Briar Creek.
250	*Pæcilichthys sagitta*	Etheostoma sagitta	Wolf Creek.
251	*Etheostoma cumberlandicum*	Etheostoma flabellare cumberlandicum.	Wolf, Briar, Yellow, and Gap Creeks, and Clear Fork of the Cumberland.

1887. CHAS. H. GILBERT.

Descriptions of New and Little Known Etheostomoids. <Proc. U. S. Nat. Mus., vol. X, 1887 (May 17), pp. 47–64.

In the summer of 1884 Prof. Gilbert and Prof. Joseph Swain spent some time making collections of fishes in eastern Kentucky and Tennessee. The new and little known darters obtained were described in this paper. They are as follows:

Etheostoma squamatus Gilbert and Swain, new species (=*Hypohomus squamatus*), a single specimen from French Broad River at mouth of Wolf Creek, Cocke County, Tenn.; *Etheostoma nianguæ spilotum* Gilbert, new subspecies (=*Hypohomus spilotus*), 12 specimens from Sturgeon Creek near Travelers Rest, Owsley County, Ky.; *Etheostoma zonale* Cope, Cypress Creek, Florence, Ala., Rolling Fork and Rockcastle River, Ky.; *Etheostoma* (*Rhothœca*) *blennius* Gilbert and Swain, new species, one specimen (the type) from Cox Creek and one from Shoal Creek, both near Florence, Ala.; *Etheostoma* (*Etheostoma*) *saxatile* Hay (=*Ulocentra stigmæa*), tributaries of Clinch River near Clinton, Tenn.; *Etheostoma* (*Etheostoma*) *luteovinctum* Gilbert and Swain, new species, 5 specimens from Stone River near Nashville; *Etheostoma* (*Etheostoma*) *tuscumbia* Gilbert and Swain, new species, (=*Psychromaster tuscumbia*), stream flowing from the large spring at Tuscumbia, Ala.

Other species contained in the collections made by Profs. Gilbert and Swain on this expedition but never published are the following, which are recorded in our distributional list as "Gilbert and Swain, 1884, collectors:"

Noturus flavus from the Tennessee at Florence, *Noturus eleutherus* from Hines Creek, Clinton, Tenn., *Noturus miurus* from the Clinch River, Clinton, Tenn., *Ameiurus natalis* from Huntsville, Ala., *Ameiurus nigricans* from the Tennessee at Florence, *Ictalurus furcatus* from the Tennessee at Florence, *Erimyzon sucetta* from the Tennessee at Florence, *Moxostoma duquesnii* from Duck River, Columbia, Tenn., *Moxostoma anisurum* from Richland Creek, Pulaski, Tenn., *Lagochila lacera* from the Tennessee at Florence, and Richland Creek, Pulaski, Tenn., *Campostoma anomalum* from Clinch River, Clinton, Tenn., Tennessee River at Florence, and Wolf Creek, Cocke County, Tenn., *Chrosomus erythrogaster* from the Tennessee at Florence, and Clinch River, Clinton, Tenn., *Cliola vigilax* from Clinch River, Clinton, Tenn., Stone River at Nashville, and Richland Creek, Pulaski, Tenn., *Notropis spectrunculus* from the Tennessee at Florence, Wolf Creek, Cocke County, Tenn., *Notropis galacturus* from Clinch River, Clinton, Tenn., Wolf Creek, Cocke County, Tenn., Harpeth River, Franklin, Tenn., and Duck River at Columbia, Tenn., *Notropis coccogenis* from Wolf Creek, Cocke County, Tenn., and Tennessee River at Florence, *Notropis ariommus* from the Tennessee at Florence, *Notropis whipplii* from the Tennessee at Florence, *Notropis lythrurus* from the Tennessee at Florence, and Richland Creek, Pulaski, Tenn., *Notropis lirus* from the Tennessee at Florence, *Notropis micropteryx* from Richland Creek, Pulaski, Tenn., *Hybognathus nuchale* from the Tennessee near Huntsville, *Phenacobius uranops* from Duck River, Columbia, Tenn., *Rhinichthys atronasus obtusus* from the Tennessee at Florence and Huntsville, *Hybopsis amblops* from the Tennessee at Florence, and Wolf Creek, Cocke County, Tenn., *Hybopsis dissimilis* from the Tennessee at Florence, *Hybopsis monacus* from Shoal Creek near Florence, *Hybopsis hyostomus* from Clinch River, Clinton, Tenn., *Phoxinus flammeus* from the Tennessee near Huntsville, *Clupea chrysochloris* from Clinch River, Clinton, Tenn., *Fundulus catenatus* from the Tennessee at Florence, *Zygonectes notatus* from the Tennessee at Florence, *Esox reticulatus* from the Tennessee at Florence, *Labidesthes sicculus* from Tuscumbia and Florence, *Chænobrythus gulosus* from Cypress Creek at Florence, *Lepomis megalotis* from the Tennessee at Florence, Richland Creek, Pulaski, Tenn., and Tuscumbia, *Lepomis pallidus* from the Tennessee at Florence, *Etheostoma simoterum* from Cypress Creek near Florence, Richland Creek, Pulaski, Tenn., Duck River, Columbia, Tenn., Harpeth River, Franklin, Tenn., Hines Creek, Clinton, Tenn., and Tennessee River at Huntsville, *Etheostoma blennioides* from Duck River, Columbia, Tenn., French Broad River at Big Creek, Tenn., and Clinch River, Clinton, Tenn., *Etheostoma caprodes* from Clinch River, Clinton, Tenn., *Etheostoma evides* from Duck River, Columbia, Tenn., *Etheostoma scierum* serrula from Bull Run, Hershells, Tenn., *Etheostoma zonale* from Cypress Creek at Florence and Wolf Creek, Cocke County, Tenn., *Etheostoma camurum* from Duck River, Columbia, Tenn., *Etheostoma maculatum*, from Clinch River, Clinton, Tenn., and Shoal Creek near Florence, *Etheostoma rufilineatum* from Shoal Creek at Florence, and Clinch River, Clinton, Tenn., *Etheostoma flabellare* from Bull Run, Hershells, Tenn., Big Creek, Tenn., Cypress Creek at Florence, and Clinch River, Clinton, Tenn., *Etheostoma squamiceps* from Tuscumbia, Ala., Cypress Creek at Florence, Harpeth River at Franklin, Tenn., and Duck River at Columbia, Tenn., *Etheostoma saxatile* from Bull Run at Hershells, Tenn., and Clinch River at Clinton, Tenn., *Etheostoma cæruleum* from Cypress Creek at Florence, *Aplodinotus grunniens* from the Tennessee at Florence, *Aphredoderus sapanus* from creek near Florence, *Cottus richardsoni* from Wolf Creek, Cocke County, Tenn., the Tennessee at Florence and Huntsville, Clinch River, Clinton, Tenn.

These are all referred to as "Gilbert and Swain, 1884, collectors."

1888. DAVID STARR JORDAN.

A Manual of the Vertebrate Animals of the Northern United States including the District North and East of the Ozark Mountains, South of the Laurentian Hills, North of the Southern Boundary of Virginia, and East of the Missouri River, inclusive of Marine Species, by David Starr Jordan, president of the University of Indiana. Fifth edition, entirely rewritten and much enlarged. Chicago. A. C. McClurg & Co. 1888. pp. i–iii+1–375.

In that volume the following species are mentioned from definite streams of the region covered by this paper:

Page.	Species as recorded.	Present identification.	Locality.
48	Moxostoma crassilabre	Moxostoma breviceps	Ohio River.
49	Lagochila lacera	Lagochila lacera	Clinch River; Chicakmauga River.
56	Notropis spectrunculus	Notropis spectrunculus	Tennessee River.
59	Notropis lacertosus	Notropis lacertosus	Holston River.
60	Nortopis leuciodus	Nortopis leuciodus	Do.
61	Notropis telescopus	Notropis telescopus	Tennessee River.
63	Phenacobius uranops	Phenacobius uranops	Do.
64	Hybopsis monachus	Hybopsis monacus	Do.
67	Phoxinus estor	Leuciscus vandoisulus	Tennessee and Cumberland Rivers.
68	Phoxinus flammeus	Leuciscus flammeus	Tennessee River.
70	Hiodon selenops	Hiodon selenops	Cumberland River.
83	Amblyopsis spelæus	Amblyopsis spelæus	Subterranean streams in Kentucky and Indiana, Mammoth Cave, etc.
83	Typhlichthys subterraneus	Typhlichthys subterraneus	Caves and wells in Kentucky, Tennessee, and Alabama.
83	Chologaster agassizii	Chologaster agassizii	Subterranean streams in Tennessee and Kentucky.
123	Etheostoma asprellus	Crystallaria asprella	Ohio River at Rising Sun, Ind.
124	Etheostoma susanæ	Boleosoma susanæ	Cumberland River, abundant in south Kentucky.
125	Etheostoma simoterum	Ulocentra simotera	Tennessee and Cumberland Basins.
128	Etheostoma aurantiacum	Hypohomus aurantiacus	Upper Tennessee River.
129	Etheostoma nianguæ spilotum	Hypohomus spilotus	Kentucky River.
129	Etheostoma squamatum	Hypohomus squamatus	French Broad River.
130	Etheostoma rufolineatum	Etheostoma rufilineatum	Do.
131	Etheostoma vulneratum	Etheostoma vulneratum	Do.
131	Etheostoma flabellare cumberlandicum.	Etheostoma flabellare cumberlandicum.	Cumberland River.
132	Etheostoma sagitta	Etheostoma sagitta	Cumberland River, Ky.
132	Etheostoma virgatum	Etheostoma virgatum	Rockcastle River, Ky.
133	Etheostoma luteovinctum	Etheostoma luteovinctum	Stone River, Tenn.

1888a. DAVID STARR JORDAN.

Descriptions of fourteen species of fresh-water fishes collected by the United States Fish Commission in the summer of 1888. <Proc. U. S. Nat. Mus., vol. XI, 1888 (July 5, 1889), pp. 351–362, pls. XLIII–XLV.

A large part of the summer of 1888 was spent by Dr. Jordan in an exploration of the streams of Virginia and North Carolina, under the auspices of the United States Fish Commission. In this work he was assisted by Prof. Oliver P. Jenkins, then of DePauw University; Barton W. Evermann, then of the Indiana State Normal School; and Seth E. Meek, then of Coe College, Cedar Rapids, Iowa.

The exploration included the headwaters of the Holston and French Broad Rivers, from which the following new species were described in the paper cited above:

Hybopsis watauga from North Fork of the Holston at Saltville, Va., and Watauga River near Elizabethton, Tenn.; *Etheostoma verecundum* (=*Ulocentra veracundum*) from Middle Fork of the Holston, 5 miles south of Glade Spring, Va.; *Etheostoma swannanoa* from South Fork of the Swannanoa at Black Mountain, N. C., South Fork of the Holston at Holstein Mills, Va., and Middle Fork of the Holston at Marion, Va.

1889. JAMES A. HENSHALL.

On a Collection of Fishes from East Tennessee. <Journ. Cincinnati Society of Natural History, vol. XII, 1889 (read June 4, 1889), pp. 31–33.

In that paper Dr. Henshall recorded five species of fishes, all from a "small tributary of the Tennessee at Whiteside, Tenn.," where they were collected by Charles Dury, of Cincinnati.

The list is as follows:

Page.	Species as recorded.	Present identification.
31	Campostoma anomalum	Campostoma anomalum.
31	Chrosomus erythrogaster	Chrosomus erythrogaster.
32	*Etheostoma duryi*	Ulocentra simotera.
32	*Etheostoma formosa*	Etheostoma cœruleum.
32	Cottus richardsoni	Cottus ictalops.

1889. DAVID STARR JORDAN.

Report of Explorations made during the Summer and Autumn of 1888 in the Alleghany Region of Virginia, North Carolina, and Tennessee, and in Western Indiana, with an Account of the Fishes Found in Each of the River Basins of those Regions. <Bull. U. S. Fish Comm., VIII, 1888 (1889), pp. 97–173, pls. XIII–XV (figs. 1–13).

The explorations indicated above were made under the auspices of the United States Fish Commission by Dr. Jordan, assisted by Prof. Oliver P. Jenkins, then of Depauw University; Prof. Barton W. Evermann, then of the Indiana State Normal School; and Prof. Seth E. Meek, then of Coe College. Profs. Jordan and Jenkins began field work at Luray, Va., July 25. They were joined at Lexington, Va., July 27, by Prof. Evermann, who remained with them until the party reached Hot Springs, N. C., August 14, when he returned to Indiana to take up work on the Wabash River. Prof. Meek joined the party at Hot Springs August 14. Dr. Jordan returned to Indiana, August 27, from Greensboro, N. C., Profs. Jenkins and Meek continuing in the field until September 8, when they brought the investigations to a close at Clifton Forge, Va.

Streams were examined and collections were made within the region covered by the present paper as follows:

Holston River.—South Fork of Holston River at Holstein Mills, Va., August 7; Middle Fork of Holston River at Marion, Va., August 7, and near Glade Springs, Va., August 8; North Fork of Holston River at Saltville, Va., August 9; Beaver Creek, 4 miles south of Bristol, Tenn., August 10; Watauga River and Doe River near Elizabethton, Tenn., August 11.

French Broad River.—French Broad River and Spring Creek at Hot Springs, N. C., August 13 and 14; North Fork of Swannanoa River at Burnett's mill near foot of Black Mountain, N. C., August 20; South Fork of Swannanoa River (Hat Creek) at Black Mountain station, August 21; Swannanoa River near Asheville, N. C., August 15 and 17.

The species obtained are indicated in the following tabular statement:

Page.	Species as recorded.	Present identification.	Locality.
143	Noturus miurus	Schilbeodes miurus	North Fork of the Holston.
151	Noturus eleutherus	Schilbeodes eleutherus	French Broad River.
143, 151	Leptops olivaris	Leptops olivaris	Watauga River; French Broad River; South Fork of Swannanoa.
151	Ictalurus punctatus	Ictalurus punctatus	French Broad River.
143	Catostomus teres	Catostomus commersonii	South Fork of Holston; Middle Fork of the Holston at Marion and Glade Spring; Beaver Creek; Watauga River.
151	do	do	Swannanoa River; South Fork of Swannanoa; Spring Creek.
144	Catostomus nigricans	Hypentelium nigricans	South Fork of the Holston; Middle Fork of Holston at Marion and Glade Spring; Beaver Creek; Watauga River; Doe River.
151	do	do	Swannanoa River; South Fork of Swannanoa; Spring Creek.
144	Moxostoma duquesnei	Moxostoma aureolum	Middle Fork of Holston at Marion and Glade Spring; North Fork of Holston; Beaver Creek; Watauga River.

Page.	Species as recorded.	Present identification.	Locality.
151	Moxostroma duquesnei	Moxostroma aureolum	French Broad River and Spring Creek.
144	Lagochila lacera	Lagochila lacera	North Fork of Holston.
144	Campostoma anomalum	Campostoma anomalum	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; North Fork of Holston; Beaver Creek; Watauga and Doe Rivers.
152	do	do	Spring Creek; Swannanoa River; South Fork of Swannanoa.
144	Notropis spectrunculus	Notropis spectrunculus	Middle Fork of Holston at Marion and Glade Spring; South Fork of Holston.
152	do	do	Spring Creek; North Fork of Swannanoa; South Fork of the Swannanoa.
144	Notropis microstomus	Notropis blennius	North Fork of Holston; Doe River; Beaver Creek; Watauga River.
152	do	do	Spring Creek; French Broad River; Swannanoa River; South Fork of Swannanoa River.
152	Hybopsis dissimilis	Hybopsis dissimilis	Spring Creek; Swannanoa River.
146	Rhinichthys cataractæ	Rhinichthys cataractæ	South Fork of Holston.
146	Rhinichthys obtusus	Rhinichthys atronasus	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring.
152	do	do	South Fork of Swannanoa; North Fork of Swannanoa.
146	Phenacobius uranops	Phenacobius uranops	Middle Fork of Holston at Glade Spring; North Fork of Holston; Beaver Creek; Watauga River.
152	do	do	Spring Creek; Swannanoa River.
146	Lepomis pallidus	Lepomis pallidus	Middle Fork of Holston at Glade Spring.
152	do	do	Spring Creek.
147	Lepomis megalotis	Lepomis megalotis	North Fork of Holston.
147	Ambloplites rupestris	Ambloplites rupestris	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; Beaver Creek; Watauga River.
153	do	do	Spring Creek; Swannanoa River.
152	Notropis galacturus	Notropis galacturus	Spring Creek; Swannanoa River; South Fork of Swannanoa; South Fork of Holston; Middle Fork of Holston at Glade Spring; North Fork of Holston; Beaver Creek; Watauga and Doe Rivers.
144	Notropis megalops	Notropis cornutus	South Fork of Holston; Middle Fork of Holston at Glade Spring; North Fork of Holston; Beaver Creek; Watauga River.
144	Notropis lacertosus	Notropis lacertosus	South Fork of Holston; North Fork of Holston.
152	Notropis coccogenis	Notropis coccogenis	Spring Creek; Swannanoa River; North Fork of Swannanoa; Middle Fork of Holston at Marion and Glade Spring; South Fork of Holston; North Fork of Holston; Beaver Creek; Watauga and Doe Rivers.
144	Notropis leuciodus	Notropis leuciodus	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; North Fork of the Holston; Beaver Creek; Watauga and Doe Rivers.
152	do	do	Spring Creek; Swannanoa River; French Broad River.
145	Notropis telescopus	Notropis telescopus	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; North Fork of Holston; Watauga and Doe Rivers.
152	do	do	Spring Creek; Swannanoa River; South Fork of Swannanoa River; North Fork of Swannanoa.
145	Notropis atherinoides	Notropis atherinoides	Middle Fork of Holston at Glade Spring; North Fork of Holston; Watauga and Doe Rivers.
152	do	do	Spring Creek; Swannanoa River; French Broad River.
145	Notropis ariommus	Notropis ariommus	Watauga River.
145	Notropis rubricroceus	Notropis rubricroceus	Middle Fork of the Holston; South Fork of Holston; Doe River.
145	Hybopsis amblops	Hybopsis amblops	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; North Fork of Holston; Beaver Creek; Watauga and Doe Rivers.
152	do	do	Spring Creek; Swannanoa River.
146	Hybopsis monacus	Hybopsis monacus	North Fork of the Holston.
152	do	do	Spring Creek; Swannanoa River.
146	Hybopsis watauga	Hybopsis watauga	North Fork of Holston; Watauga River.
146	Hybopsis kentuckiensis	Hybopsis kentuckiensis	South Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; North Fork of Holston.
147	Etheostoma caprodes	Percina caprodes	North Fork of Holston; Watauga River.
153	do	do	Swannanoa River.
147	Etheostoma macrocephalum	Hadropterus macrocephalus	North Fork of Holston; Middle Fork of Holston at Glade Spring.
153	Etheostoma evides	Hadropterus evides	Spring Creek; Swannanoa River; French Broad River.
147	Etheostoma aurantiacum	Hypohomus aurantiacus	North Fork of Holston; Watauga River.
153	Etheostoma squamatum	Hypohomus squamatus	Spring Creek.
147	do	do	Watauga River.
148	Etheostoma simoterum	Ulocentra simotera	Middle Fork of Holston at Marion; South Fork of Holston; Beaver Creek.
148	Etheostoma blennioides	Diplesion blennioides	North Fork of Holston; Middle Fork of Holston at Glade Spring; Doe River.
153	do	do	Spring Creek; Swannanoa River.
148	Etheostoma swannanoa	Etheostoma swannanoa	Middle Fork of Holston River at Marion; South Fork of Holston.

Page.	Species as recorded.	Present identification.	Locality.
153	Etheostoma swannanoa	Etheostoma swannanoa	South Fork of Swannanoa River.
148	Etheostoma zonale	Etheostoma zonale	North Fork of Holston; Middle Fork of Holston at Glade Spring; Beaver Creek.
153	do	do	Spring Creek; Swannanoa River; French Broad River.
153	Etheostoma camurum	Etheostoma camurum	Spring Creek.
149	Etheostoma rufolineatum	Etheostoma rufilineatum	North Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; South Fork of Holston.
153	do	do	Spring Creek; Swannanoa River.
149	Etheostoma flabellare	Etheostoma flabellare	Middle Fork of Holston at Marion; South Fork of Holston.
153	do	do	North Fork of Swannanoa; South Fork of Swannanoa; Swannanoa River.
148	Etheostoma verecundum	Ulocentra verecunda	Middle Fork of Holston at Glade Spring.
149	Cottus bairdi	Cottus ictalops	North Fork of Holston; Middle Fork of Holston at Marion and Glade Spring; South Fork of Holston; Watauga River; Doe River.
154	do	do	Spring Creek; South Fork of Swannanoa.

1891. CHARLES H. GILBERT.

Report of Explorations made in Alabama during 1889, with Notes on the Fishes of the Tennessee, Alabama, and Escambia Rivers. <Bull. U. S. Fish Comm. for 1889 (1891) pp. 143–159.

In May and June, 1889, Prof. Philip H. Kirsch, assisted by William M. Andrews and Everett O. Jones, students in the University of Indiana, while engaged in field work for the United States Fish Commission, made collections of fishes from certain streams in the Tennessee Basin. On May 27 they examined Spring Creek at Huntsville, Ala. This stream is tributary to Pinhook Creek, which in turn is tributary to the Tennessee River. The next day they collected in Pinhook Creek near Huntsville. On June 1 collections were made near Decatur, Ala., in Veta Wright Creek, a small tributary of the Tennessee. On June 5 they examined Cypress Creek (a tributary of the Tennessee) near Florence, Ala. On June 6 collections were made at Tuscumbia, Ala., from Spring Branch, tributary to the Tennessee. On June 7 they made collections in Big Nance Creek from the mill pond near Courtland, Ala., downstream for about 3 miles. They also examined Spring Creek near Courtland. The next day collections were made near Hillsboro, Ala., in Mallett Creek, also a small southern tributary of the Tennessee.

These collections were turned over to Dr. Gilbert for study and report.

In 1884 Profs. Gilbert and Swain made collections in Shoal Creek near Florence, Ala.; Duck River near Columbia, Tenn.; and Richland Creek and Pigeon Roost Creek near Pulaski, Tenn. These collections were also reported on by Dr. Gilbert in this paper.

Following is a list of the species obtained:

Page.	Species as recorded.	Present identification.	Locality.
146	Lepidosteus osseus	Lepisosteus osseus	Richland Creek.
146	Noturus miurus	Schilbeodes miurus	Duck River and Cypress Creek.
146	Noturus flavus	Noturus flavus	Shoal Creek.
146	Ameiurus melas	Ameiurus melas	Spring Creek.
146	Ameiurus natalis	Ameiurus natalis	Mallett and Veta Wright Creeks.
146	Ictalurus punctatus	Ictalurus punctatus	Tennessee River near Florence, and Spring Creek.
146	Carpiodes difformis	Carpiodes difformis	Richland Creek.
146	Ictiobus bubalus	Ictiobus bubalus	Tennessee River near Florence.
147	Catostomus teres	Catostomus commersonii	Small tributaries of the Tennessee.
147	Catostomus nigricans	Hypentelium nigricans	Abundant.
147	Erimyzon sucetta	Erimyzon sucetta	Cypress and Veta Wright Creeks.
147	Minytrema melanops	Minytrema melanops	Moderately abundant.
147	Moxostoma macrolepidotum duquesnei.	Moxostoma aureolum	Generally abundant.
147	Moxostoma anisurum	Moxostoma anisurum	Richland and Spring Creeks.

Page.	Species as recorded.	Present identification.	Locality.
147	Lagochila lacera	Lagochila lacera	Richland and Cypress Creeks.
147	Campostoma anomalum	Campostoma anomalum	Generally abundant.
147	Chrosomus erythrogaster oreas.	Chrosomus erythrogaster oreas.	Cypress Creek.
147	Hybognathus nuchalis	Hybognathus nuchale	Spring Branch, Spring Creek, Big Nance Creek, and Pinhook Creek.
147	Pimephales notatus	Pimephales notatus	Everywhere abundant.
147	Cliola vigilax	Cliola vigilax	Spring Branch and Richland Creek.
147	Notropis spectrunculus	Notropis spectrunculus	Big Nance Creek.
147	Notropis deliciosus	Notropis blennius	Do.
147	Notropis whipplei	Notropis whipplii	Generally abundant.
147	Notropis galacturus	Notropis galacturus	Widely distributed.
147	Notropis megalops	Notropis cornutus	Everywhere abundant.
147	Notropis coccogenis	Notropis coccogenis	Cypress Creek.
148	Notropis ariommus	Notropis ariommus	Do.
148	Notropis boops	Notropis boops	Cypress Creek, Big Nance, and Veta Wright Creeks.
148	Notropis leuciodus	Notropis leuciodus	Cypress and Big Nance Creeks.
148	Notropis umbratilis fasciolaris.	Notropis umbratilis fasciolaris.	Everywhere abundant.
148	Notropis micropteryx	Notropis micropteryx	Shoal Creek.
148	Ericymba buccata	Ericymba buccata	Cypress Creek.
149	Phenacobius uranops	Phenacobius uranops	Cypress, Big Nance, Shoal, and Richland Creeks and Duck River.
149	Rhinichthys atronasus	Rhinichthys atronasus	Cypress, Pinhook, and Spring Creeks.
149	Hybopsis kentuckiensis	Hybopsis kentuckiensis	Cypress and Mallett Creeks and Duck River.
149	Hybopsis dissimilis	Hybopsis dissimilis	Shoal Creek.
149	Hybopsis amblops	Hybopsis amblops	Everywhere abundant.
149	Hybopsis monachus	Hybopsis monacus	Shoal Creek.
149	Semotilus atromaculatus	Semotilus atromaculatus	Generally abundant in ponds and sluggish streams.
149	Phoxinus vittatus	Leuciscus flammeus	Spring Creek, Spring Branch, and Veta Wright Creek.
149	Opsopœodus emiliæ	Opsopœodus emiliæ	Mallett Creek.
149	Notemigonus chrysoleucas	Notemigonus crysoleucas	Veta Wright Creek.
149	Fundulus catenatus	Fundulus catenatus	Cypress, Shoal, Pinhook, and Richland Creeks.
149	*Fundulus albolineatus*	Fundulus albolineatus	Spring Creek.
150	Zygonectes notatus	Fundulus notatus	Everywhere abundant.
150	Lucius vermiculatus	Lucius vermiculatus	Cypress and Big Nance Creeks.
150	Labidesthes sicculus	Labidesthes sicculus	Cypress Creek, Spring Branch, Big Nance, and Spring Creeks.
149	Aphredoderus sayanus	Aphredoderus sayanus	Cypress Creek.
149	Pomoxis sparoides	Pomoxis sparoides	Mallett and Veta Wright Creeks.
150	Ambloplites rupestris	Ambloplites rupestris	Cypress, Big Nance, Spring, and Richland Creeks.
150	Chænobryttus gulosus	Chænobryttus gulosus	Cypress and Mallett Creeks.
150	Lepomis pallidus	Lepomis pallidus	Generally abundant.
150	Lepomis megalotis	Lepomis megalotis	Everywhere abundant.
150	Micropterus dolomieu	Micropterus dolomieu	Cypress Creek.
150	Micropterus salmoides	Micropterus salmoides	Abundant.
150	Etheostoma nigrum	Boleosoma nigrum	Cypress Creek and Spring Branch.
150	Etheostoma stigmæum	Ulocentra stigmæa	Cypress and Big Nance Creeks.
150	Etheostoma simoterum	Ulocentra simoterum	Everywhere very abundant.
150	Etheostoma blennius	Etheostoma blennius	Cypress Creek.
150	Etheostoma blennioides	Etheostoma blennioides	Cypress, Shoal, and Big Nance Creeks
151	Etheostoma caprodes	Percina caprodes	Generally abundant.
151	Etheostoma scierum	Hadropterus scierus	Spring Creek.
151	Etheostoma aspro	Hadropterus aspro	Spring Branch and Mallett Creek.
151	Etheostoma evides	Hadropterus evides	Duck River.
151	Etheostoma zonale	Etheostoma zonale	Cypress, Shoal, and Big Nance Creeks.
151	Etheostoma maculatum	Etheostoma maculatum	Cypress Creek and Duck River.
151	Etheostoma rufolineatum	Etheostoma rufilineatum	Cypress and Shoal Creeks.
151	Etheostoma flabellare	Etheostoma flabellare	Cypress, Spring, and Pinhook Creeks.
151	Etheostoma squamiceps	Etheostoma squamiceps	Generally abundant.
151	Etheostoma coeruleum	Etheostoma cœruleum	Cypress and Spring Creeks.
151	Etheostoma tuscumbia	Etheostoma tuscumbia	Spring Branch and Veta Wright Creek.
151	Cottus bairdi	Cottus ictalops	Generally abundant in clear cold streams.

1892. PHILIP H. KIRSCH.

Notes on the Streams and Fishes of Clinton County, Ky., with a Description of a New Darter. <Bull. U. S. Fish Comm., vol. x, 1890 (1892), pp. 289–292.

In the autumn of 1889 and spring of 1890 Dr. Kirsch examined many of the streams in Clinton County, Ky., and made collections of fishes in seven of them, namely, Indian Creek, Willis Creek, Wolf River, Ill-will Creek, Spring Creek, Smith Creek. and Albany Branch.

Indian Creek is directly tributary to the Cumberland River. Collections were made from it in its lower course and in the deep gorge below Seventy-six Falls in its principal western branch. Willis Creek also flows directly into the Cumberland and was examined from the "three forks" to its mouth, a distance of about 5 miles. Wolf River is a branch of Obeys River, which in turn is directly tributary to the Cumberland.

Only a few specimens were obtained from Wolf River. Ill-will and Spring Creeks flow into Wolf River. Collections were made in Spring Creek from its middle course between the mouths of Albany Branch and Smith Creek, a distance of 2 miles. Smith Creek flows into Spring Creek and was investigated for its entire length. Albany branch also flows into Spring Creek and was examined in its upper and middle courses.

The list of species is as follows:

Species as recorded.	Present identification.	Locality.
Polyodon spathula	Polyodon spathula	Indian Creek and Wolf River.
Lepisosteus osseus	Lepisosteus osseus	Indian, Willis, and Ill-will Creeks.
Ictalurus punctatus	Ictalurus punctatus	Indian and Willis Creeks.
Ameiurus nebulosus	Ameiurus nebulosus	Indian, Smith, and Albany Creeks.
Ictiobus cyprinella	Ictiobus cyprinella	Indian Creek.
Catostomus commersonii	Catostomus commersonii	Indian and Willis Creeks and Wolf River.
Catostomus nigricans	Hypentelium nigricans	Indian, Willis, Spring, and Albany Creeks.
Campostoma anomalum	Campostoma anomalum	Willis, Spring, Smith, and Albany Creeks.
Chrosomus erythrogaster	Chrosomus erythrogaster	Indian, Smith, and Albany Creeks.
Pimephales notatus	Pimephales notatus	Do.
Notropis whipplei	Notropis whipplii	Indian Creek.
Notropis galacturus	Notropis galacturus	Indian, Willis, Spring, and Smith Creeks.
Notropis cornutus	Notropis cornutus	Indian, Willis, Spring, Smith, and Albany Creeks.
Notropis leuciodus	Notropis leuciodus	Smith Creek.
Notropis umbratilis cyanocephalus	Notropis umbratilis lythrurus	Indian, Willis, Spring, Smith, and Albany Creeks.
Notropis telescopus	Notropis telescopus	Indian Creek.
Rhinichthys atronasus	Rhinichthys atronasus	Indian, Willis, Smith, and Albany Creeks.
Hybopsis amblops	Hybopsis amblops	Indian Creek.
Hybopsis kentuckiensis	Hybopsis kentuckiensis	Spriug, Smith, and Albany Creeks.
Clupea chrysochloris	Pomolobus chrysochloris	Willis Creek.
Anguilla chrysypa	Anguilla chrisypa	Ill-will Creek and Wolf River.
Fundulus catenatus	Fundulus catenatus	Indian and Willis Creeks.
Ambloplites rupestris	Ambloplites rupestris	Indian, Spring, Smith, and Albany Creeks.
Lepomis megalotis	Lepomis megalotis	Indian Creek.
Apomotis cyanellus	Apomotis cyanellus	Indian, Willis, Spring, and Smith Creeks.
Diplesion blennioides	Diplesion blennioides	Indian, Spring, and Smith Creeks.
Percina caprodes	Percina caprodes	Willis Creek.
Etheostoma rufilineatum	Etheostoma rufilineatum	Indian Creek.
Etheostoma flabellare cumberlandicum	Etheostoma flabellare cumberlandicum.	Indian, Smith, and Albany Creeks.
Etheostoma cœruleum	Etheostoma cœruleum	Indian Smith Willis, Spring, and Albany Creeks.
Etheostoma obeyense	Etheostoma obeyense	Indian, Spring, Smith, and Albany Creeks.
Stizostedion canadense	Stizostedion canadense	Indian Creek.

1893. PHILIP H. KIRSCH.

Notes on a Collection of Fishes from the Southern Tributaries of the Cumberland River in Kentucky and Tennessee. <Bull. U. S. Fish Comm., vol. XI, 1891 (May 25, 1893), pp. 257–265.

During the period from August 18 to September 9, 1891, Dr. Kirsch made collections of fishes in certain southern tributaries of the Cumberland River between Nashville and the Cincinnati Southern Railroad, as follows:

West Fork of Stone River for a distance of 1 mile below Murfreesboro, Tenn., August 20; Spring Creek at Springcreek station, Tenn., 12 miles from its mouth, August 21; Round Lick Creek at Watertown, Tenn., August 22; Caney Fork River, 1 mile west of Lancaster, Tenn., August 24; Smith Fork (a tributary of Caney Fork) near Lancaster, August 24; Roaring River, a few miles from Windle, Tenn., August 30; Spring Creek (a tributary of Roaring River) at Netherland, Tenn., August 25; Obeys River at Olympus, Tenn., August 28; Eagle Creek (a tributary of Obeys River) near Olympus, August 27; Wolf River (a tributary of Obeys River) 3 miles north of Byrdstown, Tenn., August 28; Cumberland River near the mouth of Willis Creek, Cumberland County, Ky., September 1; Willis Creek at its mouth, September 1; Beaver Creek above and below McCackney's milldam, Wayne County, Ky., September 3; Otter Creek (a tributary of Beaver Creek) near Jones's milldam on the Monticello and Albany road, September 2; Little South Fork of Cumberland River near the mouth of Canada Creek, 8 miles above its mouth, September 4; Big South Fork of Cumberland River near the mouth of Rock Creek, 7 miles west of Whitley station, Ky., September 7; Rock Creek in its lower course near Whitley station, Ky., September 7; New River (a tributary of Big South Fork) at New River station, September 8; Brimstone Creek near New River station, September 9.

The following table shows the species obtained and their distribution in the streams examined:

Page.	Species as recorded.	Present identification.	Locality.
262 264 265	Lepisosteus osseus	Lepisosteus osseus	Smith Fork; Obeys River; Cumberland River.
260 261	Ameiurus natalis	Ameiurus natalis	Spring Creek; Round Lick Creek.
262	Ameiurus nigricans	Ameiurus lacustris	Smith Fork.
264	Ameiurus nebulosus	Ameiurus nebulosus	Obeys River; Beaver Creek; Otter Creek.
262	Ictalurus punctatus	Ictalurus punctatus	Smith Fork.
264	do.	do.	Obeys River.
262	Leptops olivaris	Leptops olivaris	Smith Fork.
262	Noturus flavus	Noturus flavus	Smith Fork; Obeys River; Eagle Creek.
260	Catostomus nigricans	Hypentelium nigricans	West Fork of Stone River.
262	do.	do.	Spring Creek; Caney Fork River.
263	do.	do.	Smith Fork.
264	do.	do.	Roaring River.
265 266 267	do.	do.	Obeys River; Eagle Creek; Wolf River; Little South Fork; Rock Creek; Willis Creek; Beaver Creek; Canada Creek; New River; Otter Creek; Big South Fork; Brimstone Creek.
260	Moxostoma macrolepidotum duquesnei.	Moxostoma aureolum	West Fork of Stone River.
262	do.	do.	Spring Creek; Caney Fork River; Smith Fork.
264	do.	do.	Obeys River; Eagle Creek; Wolf River.
265	do.	do.	Cumberland River; Willis Creek; Beaver Creek; Otter Creek.
266	do.	do.	Little South Fork.
267	do.	do.	Canada Creek; Big South Fork; Rock Creek.
260	Lagochila lacera	Lagochila lacera	West Fork of Stone River; Little South Fork.
267	do.	do.	Canada Creek.
262	Ictiobus difformis	Carpiodes difformis	Caney Fork River.
265	do.	do.	Smith Fork; Willis Creek.
263	Catostomus teres	Catostomus commersonii	Spring Creek, tributary to Roaring River.
260	Campostoma anomalum	Campostoma anomalum	West Fork of Stone River; Spring Creek.
261	do.	do.	Round Lick Creek.
262	do.	do.	Smith Fork.
263	do.	do.	Roaring River.
264	do.	do.	Eagle Creek; Wolf River.
265	do.	do.	Willis Creek.
266	do.	do.	Beaver and Otter Creeks.
267	do.	do.	Little South Fork; Canada Creek; Rock Creek; New River; Brimstone Creek.
260	Pimephales notatus	Pimephales notatus	West Fork of Stone River.
261	do.	do.	Spring Creek.
262	do.	do.	Round Lick Creek; Smith Fork.
264	do.	do.	Wolf River; Beaver and Otter Creeks.
266	do.	do.	Little South Fork.
267	do.	do.	Canada Creek.
262	Hybognathus nuchalis	Hybognathus nuchales	Smith Fork.
263	Chrosomus erythrogaster	Chrosomus erythrogaster	Roaring River; Spring Creek, tributary to Roaring River; Beaver Creek.
261	Semotilus atromaculatus	Semotilus atromaculatus	Round Lick Creek; Roaring River and Spring Creek, its tributary.
263	do.	do.	Beaver Creek.
266	do	do.	Canada Creek.
260	Notropis boops	Notropis shumardi	West Fork of Stone River.
264	do.	do.	Wolf River.
260	Notropis whipplei	Notropis whipplii	West Fork of Stone River; Spring Creek.
262	do.	do.	Caney Fork River; Smith Fork.
264	do.	do	Obeys River; Eagle Creek; Wolf River.
265	do.	do	Willis Creek.
266	do.	do	Beaver and Otter Creeks.
267	do.	do	Big South Fork; Rock Creek; New River; Brimstone Creek.
260	Notropis galacturus	Notropis galacturus	West Fork of Stone River.
261	do.	do	Spring Creek.
262	do.	do	Smith Fork.
263	do.	do	Roaring River.
264	do.	do	Obeys River; Eagle Creek; Wolf River.
265	do.	do	Willis Creek.

Page.	Species as recorded.	Present identification.	Locality.
266	Notropis galacturus	Notropis galacturus	Beaver and Otter Creeks.
267	.....do	.....do	Little South Fork; Rock Creek; New River.
260	Notropis megalops	Notropis cornutus	West Fork of Stone River.
261	.....do	.....do	Spring Creek; Round Lick Creek.
262	.....do	.....do	Smith Fork.
264	.....do	.....do	Obeys River; Eagle Creek; Wolf River.
265	.....do	.....do	Willis Creek.
266	.....do	.....do	Beaver and Otter Creeks.
267	.....do	.....do	Little South Fork; Canada Creek.
260	Notropis telescopus	Notropis telescopus	West Fork of Stone River.
264	.....do	.....do	Obeys River; Eagle Creek.
265	.....do	.....do	Willis Creek.
267	.....do	.....do	Canada Creek; Big South Fork; Rock Creek.
261	Notropis umbratilis cyanocephalus.	Notropis umbratilis lythrurus	Spring Creek; Round Lick Creek.
263	.....do	.....do	Roaring River.
264	.....do	.....do	Eagle Creek; Wolf River.
265	.....do	.....do	Cumberland River; Willis Creek.
266	.....do	.....do	Otter Creek.
267	.....do	.....do	Canada Creek; Big South Fork; New River; Brimstone Creek.
261	Notropis atherinoides	Notropis atherinoides	Spring Creek; Round Lick Creek.
262	.....do	.....do	Smith Fork.
264	.....do	.....do	Obeys River; Eagle Creek; Wolf River.
265	.....do	.....do	Cumberland River.
267	.....do	.....do	Little South Fork; Canada Creek; Big South Fork; Rock Creek; Brimstone Creek.
261	Notropis ariommus	Notropis ariommus	Round Lick Creek.
267	.....do	.....do	Rock Creek.
260	Hybopsis amblops	Hybopsis amblops	West Fork of Stone River.
261	.....do	.....do	Spring Creek.
262	.....do	.....do	Smith Fork; Eagle Creek; Wolf River.
264	.....do	.....do	Otter Creek.
266	.....do	.....do	Little South Fork.
267	.....do	.....do	Canada Creek; Rock Creek.
260	Hybopsis kentuckiensis	Hybopsis kentuckiensis	West Fork of Stone River.
261	.....do	.....do	Spring Creek.
263	.....do	.....do	Roaring River; Eagle Creek; Wolf River.
264	.....do	.....do	Beaver and Otter Creeks.
266	.....do	.....do	Little South Fork.
267	.....do	.....do	Canada Creek; Big South Fork; New River; Brimstone Creek.
262	Hybopsis watauga	Hybopsis watauga	Caney Fork River; Smith Fork.
264	.....do	.....do	Obeys River.
262	Hybopsis storerianus	Hybopsis storerianus	Smith Fork.
263	Rhinichthys atronasus	Rhinichthys atronasus	Roaring River.
265	.....do	.....do	Cumberland River.
264	Phenacobius uranops	Phenacobius uranops	Obeys River; Eagle Creek; Wolf River.
265	.....do	.....do	Willis Creek.
260	Zygonectes notatus	Fundulus notatus	West Fork of Stone River.
261	.....do	.....do	Spring Creek.
261	Fundulus catenatus	Fundulus catenatus	Spring Creek; Round Lick Creek.
264	.....do	.....do	Obeys River; Eagle Creek; Wolf River.
265	.....do	.....do	Willis Creek.
266	.....do	.....do	Beaver and Otter Creeks.
268	.....do	.....do	Little South Fork; Canada Creek.
264	Clupea chrysochloris	Pomolobus chrysochloris	Obeys River.
265	.....do	.....do	Willis Creek.
260	Labidesthes sicculus	Labidesthes sicculus	West Fork of Stone River.
261	.....do	.....do	Spring Creek.
264	.....do	.....do	Obeys River.
260	Lepomis pallidus	Lepomis pallidus	West Fork of Stone River.
261	.....do	.....do	Spring Creek.
260	Lepomis megalotis	Lepomis megalotis	West Fork of Stone River.
261	.....do	.....do	Spring Creek; Round Lick Creek.
262	.....do	.....do	Smith Fork.
264	.....do	.....do	Obeys River; Eagle Creek; Wolf River.
266	.....do	.....do	Beaver and Otter Creeks.
268	.....do	.....do	Little South Fork; Canada Creek; Big South Fork; Brimstone Creek.
266	Lepomis cyanellus	Apomotis cyanellus	Beaver Creek.
262	Ambloplites rupestris	Ambloplites rupestris	Smith Fork.
263	.....do	.....do	Roaring River; Spring Creek, tributary to Roaring River.
264	.....do	.....do	Obeys River; Wolf River.
268	.....do	.....do	Little South Fork; Brimstone Creek.
260	Micropterus dolomieu	Micropterus dolomieu	West Fork of Stone River.
262	.....do	.....do	Smith Fork.
263	.....do	.....do	Roaring River.
264	.....do	.....do	Obeys River; Eagle Creek; Wolf River.
265	.....do	.....do	Cumberland River.
266	.....do	.....do	Otter Creek; Little South Fork.
268	.....do	.....do	Big South Fork; Brimstone Creek; Canada Creek.
261	.....do	.....do	Spring Creek.
265	Micropterus salmoides	Micropterus salmoides	Cumberland River; Willis Creek.
268	.....do	.....do	Big South Fork; Rock Creek; New River; Brimstone Creek.

Page.	Species as recorded.	Present identification.	Locality.
260	Etheostoma simoterum atripinnis.	Ulocentra simotera	West Fork of Stone River; Spring Creek; Round Lick Creek.
262	do.	do.	Smith Fork.
264	do.	do.	Eagle Creek.
268	do.	do.	Canada Creek.
260	Etheostoma caprodes	Percina caprodes	West Fork of Stone River.
261	do.	do.	Spring Creek.
262	do.	do.	Smith Fork.
264	do.	do.	Obeys River; Eagle Creek; Wolf River.
265	do.	do.	Willis Creek; Otter Creek.
266	do.	do.	Little South Fork; Big South Fork.
268	do.	do.	New River; Brimstone Creek.
264	Etheostoma macrocephalum	Hadropterus macrocephalus	Obeys River: Eagle Creek.
268	do.	do.	Little South Fork.
262	Etheostoma aspro	Hadropterus aspro	Smith Fork.
265	do.	do.	Cumberland River.
268	do.	do.	Big South Fork; Brimstone Creek.
262	Etheostoma evides	Hadropterus evides	Caney Fork River; Smith Fork; Obeys River.
262	Etheostoma stigmæum	Ulocentra stigmæa	Smith Fork.
265	do.	do.	Willis Creek.
268	do.	do.	Little South Fork; Canada Creek; Big South Fork; Brimstone Creek.
260	Etheostoma blennioides	Diplesion blennioides	West Fork of Stone River.
261	do.	do.	Spring Creek.
262	do.	do.	Smith Fork.
263	do.	do.	Roaring River.
264	do.	do.	Obeys River; Eagle Creek; Wolf River.
266	do.	do.	Beaver and Otter Creeks; Little South Fork.
268	do.	do.	Canada Creek; Rock Creek; New River.
264	Etheostoma cinereum	Etheostoma cinereum	Obeys River; Eagle Creek; Wolf River.
268	do.	do.	Little South Fork; Canada Creek.
260	Etheostoma rufilineatum	Etheostoma rufilineatum	West Fork of Stone River.
261	do.	do.	Spring Creek.
262	do.	do.	Caney Fork River; Eagle Creek.
264	do.	do.	Little South Fork.
268	do.	do.	Big South Fork; Rock Creek.
260	Etheostoma squamiceps	Etheostoma squamiceps	West Fork of Stone River.
261	do.	do.	Spring Creek; Round Lick Creek.
263	Etheostoma cœruleum	Etheostoma cœruleum	Roaring River.
265	do.	do.	Obeys River; Eagle Creek; Wolf River; Willis Creek.
266	do.	do.	Otter Creek.
268	do.	do.	Little South Fork; Canada Creek; Big South Fork; Brimstone Creek.
265	Etheostoma obeyense	Etheostoma obeyense	Obeys River.
266	do.	do.	Beaver and Otter Creeks.
268	do.	do.	Little South Fork; Canada Creek.
265	Etheostoma zonale	Etheostoma zonale	Obeys River.
265	Etheostoma copelandi	Cottogaster copelandi	Do.
262	Stizostedion vitreum	Stizostedion vitreum	Smith Fork.
262	Aplodinotus grunniens	Aplodinotus grunniens	Do.
265	do.	do.	Cumberland River.
261	Cottus bairdi	Cottus ictalops	Round Lick Creek.
263	do.	do.	Roaring River and its tributary Spring Creek.
265	do.	do.	Obeys River.
268	do.	do.	Little South Fork.

1896. DAVID STARR JORDAN and BARTON WARREN EVERMANN.

The Fishes of North and Middle America: A Descriptive Catalogue of the Species of Fish-like Vertebrates Found in the Waters of North America North of the Isthmus of Panama. (Bull. U. S. Nat. Mus. no. 47, in 4 vol., pp. 1–3313, pls. I–CCCXCII. Pt. 1, Oct. 3, 1896; pt. 2, Oct. 3, 1898; pt. 3, Nov. 26, 1898; pt. 4, June 26, 1900.)

In this work two species are described as new from the region covered by the present paper, viz, *Ulocentra gilberti* Evermann and Thoburn (p. 1049) from Clinch River at Walkers Ford, Tenn., and *Ulocentra meadiæ* Jordan and Evermann (p. 2852), from Indian Creek, a tributary of Powell River near Cumberland Gap, Tenn.

1899. DAVID STARR JORDAN.

A Manual of the Vertebrate Animals of the Northern United States including the District North and East of the Ozark Mountains, South of the Laurentian Hills, North of the Southern Boundary of Virginia, and East of the Missouri River, inclusive of Marine Species. By David Starr Jordan, president of Leland Stanford Junior University. (Eighth edition, newly revised and enlarged. 1899. pp. i–vi+1–397. Chicago. A. C. McClurg & Co.)

The following species are mentioned as inhabiting certain named streams in the region covered in this book:

Page.	Species as recorded.	Present identification.	Locality.
48	Moxostoma crassilabre	Moxostoma breviceps	Ohio River.
56	Notropis spectrunculus	Notropis spectrunculus	Tennessee River.
59	Notropis lacertosus	Notropis lacertosus	Holston River.
60	Notropis leuciodus	Notropis leuciodus	Do.
61	Notropis telescopus	Notropis telescopus	Tennessee River.
63	Phenacobius uranops	Phenacobius uranops	Do.
65	Hybopsis monachus	Hybopsis monacus	Do.
67	Phoxinus estor	Leuciscus vandoisulus	Cumberland and Tennessee Rivers.
68	Phoxinus flammeus	Leuciscus flammeus	Tennessee River.
70	Hiodon selenops	Hiodon selenops	Cumberland River.
83	Amblyopsis spelæus	Amblyopsis spelæus	Subterranean streams of Kentucky and Indiana, Mammoth Cave, etc.
83	Typhlichthys subterraneus	Typhlichthys subterraneus	Caves and wells in Kentucky, Tennessee, and Alabama.
83	Chologaster agassizii	Chologaster agassizii	Subterranean streams in Kentucky and Tennessee.
123	Etheostoma asprellus	Crystallaria asprella	Ohio River at Rising Sun, Ind.
124	Etheostoma susanæ	Boleosoma susanæ	Cumberland River; abundant in southern Kentucky.
125	Etheostoma simoterum	Ulocentra simotera	Cumberland and Tennessee Basins.
128	Etheostoma aurantiacum	Hypohomus aurantiacus	Upper Tennessee River.
129	Etheostoma nianguæ spilotum.	Hypohomus spilotus	Kentucky River.
129	Etheostoma squamatum	Hypohomus squamatus	French Broad River.
130	Etheostoma rufolineatum	Etheostoma rufilineatum	Do.
131	Etheostoma flabellare cumberlandicum.	Etheostoma flabellare cumberlandicum.	Cumberland River.
132	Etheostoma sagitta	Etheostoma sagitta	Cumberland River, Ky.
132	Etheostoma virgatum	Etheostoma virgatum	Rockcastle River.
133	Etheostoma luteovinctum	Etheostoma luteovinctum	Stone River, Tenn.
351	Catostomus rhothœcus	Catostomus rhothœcus	French Broad River.
356	Ulocentra gilberti	Ulocentra gilberti	Clinch (misprinted Church) River.
356	Ulocentra veracunda	Ulocentra veracunda	Holston River.
356	Ulocentra meadiæ	Ulocentra meadiæ	East Tennessee.
357	Etheostoma swannanoa	Etheostoma swannanoa	Upper Tennessee River.

1902. BARTON WARREN EVERMANN.

Description of a new species of shad (*Alosa ohiensis*), with notes on other food fishes of the Ohio River. <Rept. U. S. Fish Com. for 1901 (May 26, 1902), pp. 273–288, with 6 figs.

In that paper the Ohio shad (*Alosa ohiensis*) was described as a new species, the Ohio River at the Falls being the type locality.

Besides the Ohio shad that paper records 20 other species from the Ohio River, chiefly at the Falls. The list is as follows:

Page.	Species as recorded.	Present identification.	Locality.
277	*Alosa ohiensis*	Alosa ohiensis	Falls of the Ohio.
284	Polyodon spathula	Polyodon spathula	Do.
285	Acipenser rubicundus	Acipenser rubicundus	Seen by the writer at the Falls of the Ohio in March, 1886.
285	Scaphirhynchus platorhynchus.	Scaphirhynchus platorhynchus.	Falls of the Ohio.
286	Ictalurus furcatus	Ictalurus furcatus	Do.
286	Ictalurus punctatus	Ictalurus punctatus	Do.
286	Ictalurus anguilla	Ictalurus anguilla	Do.
286	Amiurus nebulosus	Ameirurus nebulosus	Do.
286	Leptops olivaris	Leptops olivaris	Do.
286	Ictiobus bubalus	Ictiobus bubalus	Do.
286	Carpiodes carpio	Carpiodes carpio	Do.
286	Cycleptus elongatus	Cycleptus elongatus	Do.
287	Carpiodes velifer	Carpiodes velifer	Do.
287	Catostomus commersonii	Catostomus commersonii	Do.
287	Moxostoma aureolum	Moxostoma aureolum	Do.
287	Cyprinus carpio	Cyprinus carpio	Do.
287	Anguilla chrysypa	Anguilla chrisypa	Do.
287	Hiodon alosoides	Hiodon alosoides	Do.
287	Dorosoma cepedianum	Dorosoma cepedianum	Do.
287	Stizostedion vitreum	Stizostedion vitreum	Do.
287	Aplodinotus grunniens	Aplodinotus grunniens	Do.

1916. BARTON WARREN EVERMANN and SAMUEL F. HILDEBRAND.
Notes on the Fishes of East Tennessee. <Bull. U. S. Bureau of Fisheries, vol. XXXIV, 1914 (Sept. 21, 1916), pp. 431–452, 13 figs.

In September and October, 1893, the writer, assisted by the late Dr. Josiah T. Scovell, of Terre Haute, Ind., and Dr. Revere R. Gurley, then scientific assistant in the United States Fish Commission, examined many of the streams and springs of east Tennessee for the purpose of selecting a site for a fish-cultural station. Incident to this work considerable collections of fishes were made. They are reported on in this paper.

DISTRIBUTIONAL LIST OF SPECIES.

Following is a list of all the species of fishes which have been recorded, so far as the writer has been able to determine, from the Cumberland and Tennessee Basins and the other streams in the States of Kentucky and Tennessee. Records from that portion of the Ohio River bordering on Kentucky and that portion of the Mississippi bordering on Kentucky and Tennessee are included.

Under each species are given (1) each stream or locality from which recorded, (2) the authority for the record, (3) the date of the record, and (4) the name under which the species was recorded (omitted when identical with the present recognized name). If the locality is a type locality, the fact is stated. Thus, under *Ameiurus melas*, "Ohio River (Rafinesque, 1820, as *Silurus melas*, type, and 1820a)," means that the species whose accepted name is *Ameiurus melas* was recorded from the Ohio River by Rafinesque in 1820 as *Silurus melas*, new species (indicated by the word "type"), and that Rafinesque again recorded it from the same place in a second paper published by him in 1820. The titles of all papers referred to will be found in the bibliography.

The number in parenthesis following each species name is that of Jordan and Evermann's Check-List of Fishes and Fishlike Vertebrates of North and Middle America. <Rept. U. S. Fish Comm. for 1895 (1896), pp. 207–584.

1. **Ichthyomyzon concolor** (Kirtland). (9.) Common lamprey.

Upper waters of the Holston River (Cope, 1869, as *Petromyzon* sp.).

2. **Lampetra wilderi** Gage. (15.) Small black lamprey.

Falls of the Ohio (Rafinesque, 1820, as *Petromyzon nigrum*, type).

3. **Polyodon spathula** (Walbaum). (148.) Spoon-bill cat; paddlefish.

French Broad River near Asheville, N. C. (Cope, 1870, as *Polyodon folium*). Abundant in the river channels (Jordan and Brayton, 1878, as *Polyodon folium*). Cumberland River (Jordan and Brayton, 1878, as *Polyodon folium*). Wolf River and Ill-will Creek, Clinton County, Ky. (Kirsch, 1892). Falls of the Ohio (Evermann, 1902).

4. **Acipenser rubicundus** Le Sueur. (152.) Lake sturgeon; common fresh-water sturgeon.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Acipenser rubicundus* and *Acipenser maculosus*; Jordan and Brayton, 1878; and Duméril, 1870, as *Acipenser paranasimos*, type). Cumberland River near Kuttawa and Tennessee River near Paducah, Ky. (Woolman, 1892). Ohio River near Louisville, Ky. (Evermann, Mar., 1886, collector).

5. **Scaphirhynchus platorhynchus** (Rafinesque). (154.) Shovel-nosed sturgeon.

Falls of the Ohio (Evermann, 1902).

6. **Lepisosteus osseus** (Linnæus). (155.) Long-nosed gar.

Lower parts of the Ohio (Rafinesque, 1818b and 1818c, as *Sarchirus Vittatus*, type). Licking River and Slate Creek (Rafinesque, 1820 ,as *Sarchirus? argenteus*). Holston River near Saltville, Va., and Dandridge, Tenn. (Cope, 1869 and 1877, as *Lepidosteus huronensis*). Cumberland River at Nashville and generally abundant in the Tennessee Basin (Jordan and Brayton, 1878, as *Lepidosteus osseus*). Stone River near Nashville (Gilbert and Swain, 1884, collectors. Big Barren River near Bowling Green, Green River near Greensburg, Tradewater River near Dawson, Cumberland River near Kuttawa, Tennessee River near Paducah, Powell River near Cumberland Gap, Obion River near Cypress, Horse Creek near Garratsville, Big Creek near Big Creek station, Lost Creek near Hazard, Troublesome Creek near

Dwarf, and Little Sandy River near its mouth, Ky. (Woolman, 1892). Indian, Willis, and Ill-will Creeks, Clinton County, Ky. (Kirsch, 1892). Smith Fork near Lancaster, Tenn., Obeys River near Olympus, Tenn., and Cumberland River near mouth of Willis Creek, Cumberland County, Ky. (Kirsch, 1893).

7. **Lepisosteus platostomus** Rafinesque. (156.) Short-nosed gar.

Cumberland and Tennessee Rivers (Rafinesque, 1820, type). Tennessee River near Huntsville (Agassiz 1854, as *Lepidosteus platostomus;* and Jordan and Brayton, 1878, as *Lepidosteus platystomus*). Tradewater River near Dawson, Tennessee River near Paducah, and Bayou de Chien near Moscow, Ky. (Woolman, 1892).

8. **Lepisosteus tristœchus** (Bloch and Schneider). (157.) Alligator gar.

Ohio River as far up as the Falls (Rafinesque, 1818a, as *Litholepis adamantinus*, type).

9. **Amia**[a] **calva** Linnæus. (159.) Bowfintus; grindle.

Tennessee River (mill ponds) near Huntsville (Agassiz, 1854, and Jordan and Brayton, 1878). Bayou de Chien near Moscow, Ky. (Woolman, 1892).

10. **Ictalurus furcatus** (Le Sueur). (214.) Forked-tail cat; blue cat; poisson bleu.

Tennessee River near Florence (Gilbert and Swain, 1884, collectors). Falls of the Ohio (Evermann, 1902).

11. **Ictalurus punctatus** (Rafinesque). (215.) Channel cat; spotted cat.

Ohio River (Rafinesque, 1818, as *Silurus punctatus*, type; 1820, as *Silurus maculatus*, type; *Silurus pallidus*, type; *Silurus cerulescens*, type; *Silurus argenteus*, type; *Silurus argyrus*, type; *Silurus argyreus* var. *erythroptera*, type; *Silurus argyrus* var. *marginatus*, type; *Silurus argyrus* var. *lateralis*, type; and *Silurus argyrus* var. *leucoptera*, type). Tennessee River (Rafinesque, 1832, as *Pimelodus lutescens*). Tennessee River near Huntsville (Agassiz, 1854, as *Pimelodus cærulescens*). French Broad River (Jordan, 1876, and Cope, 1877, as *Ictalurus cærulescens*). Cumberland River at Cumberland Falls (Evermann, 1878, collector). Very abundant in the Cumberland and Tennessee Basins (Jordan and Brayton, 1878, as *Ichthælurus punctatus*). French Broad River near Hot Springs, N. C. (Jordan, 1889). Rolling Fork of Salt River near Booth and New Haven, Rough Creek near Hartford, Pond Creek near Rockport, Big Barren River and Drake Creek near Bowling Green, Green River near Greensburg, Cumberland River near Kuttawa, Tennessee River near Paducah, Mayfield Creek near Hickory Grove, Obion River near Cypress; Bayou de Chien near Moscow, North Fork of Kentucky River near Hazard, Triplet Creek near Farmer, and Little Sandy River near its mouth, Ky. (Woolman, 1892). Indian and Willis Creeks, Clinton County, Ky. (Kirsch, 1892). Smith Fork near Lancaster, Tenn., and Obeys River near Olympus, Tenn. (Kirsch, 1893). Falls of the Ohio (Evermann, 1902). Ball Creek near Tazewell, and Clinch River at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

12. **Ictalurus anguilla** Evermann and Kendall. (216 +.) Eel cat; willow cat.

Ohio River at Louisville (Evermann, 1902).

13. **Ameiurus lacustris** (Walbaum). (219.) Great forked-tail cat; Mississippi cat.

Cumberland River near Nashville and at Cumberland Falls (Jordan and Brayton, 1878, as *Ameiurus nigricans*). South Fork near Lancaster, Tenn. (Kirsch, 1893, as *Ameiurus nigricans*).

14. **Ameiurus natalis** (Le Sueur). (224.) Yellow cat.

Ohio River (Rafianesque, 1820, as *Silurus lividus* var. *fuscatus*, type, and as *Silurus cupreus*). Tennessee River near Huntsville (Agassiz, 1854, as *Pimelodus catus*). Cumberland River near Nashville, and rather abundant in the Tennessee River (Jordan and Brayton, 1878, as *Amiurus natalis cupreus*). Clear Fork of the Cumberland near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883). Huntsville, Ala. (Gilbert and Swain, collectors, 1884). Big Barren River near Bowling Green, Green River near Greensburg, Clear Fork of Cumberland River near Pleasant View, and Mayfield Creek near Hickory Grove, Ky. (Woolman, 1892). Spring Creek near Spring Creek Station and Round Lick Creek near Watertown, Tenn. (Kirsch, 1893).

15. **Ameiurus nebulosus** (Le Sueur). (226.) Common bullhead.

Big Barren River near Bowling Green, Green River near Greensburg, Cumberland River near Pineville, Spring Creek in Clinton County, Mayfield Creek near Hickory Grove, and Bayou de Chien near Moscow, Ky. (Woolman, 1892). Indian, Smith, and Albany Creeks, Clinton County, Ky. (Kirsch,

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[a] Locally known as dogfish.

1892). Obeys River near Olympus, Tenn., Beaver Creek in Wayne County, Ky., and Otter Creek between Monticello and Albany, Ky. (Kirsch, 1893). Falls of the Ohio (Evermann, 1902).

16. **Ameiurus melas** (Rafinesque). (227.) Little black bullhead.

Ohio River (Rafinesque, 1820, as *Silurus melas*, type, and 1820a). Kentucky River (Rafinesque, 1820a, as *Silurus xanthocephalus*, type). Falls of the Ohio (Jordan, 1877a).

17. **Leptops olivaris** (Rafinesque). (230.) Big yellow cat; mud cat; goujon.

Ohio River (Rafinesque, 1818, as *Silurus olivaris*, type; 1820, as *Silurus viscosus*, type; *Silurus nebulosus* and *Silurus limosus*). Rockcastle River, Ky. (Jordan, 1876). Rockcastle River near Livingston, Ky., and Cumberland River below Cumberland Falls (Jordan and Brayton, 1878, as *Pelodichthys olivaris*). Abundant in the channels of the larger streams, several specimens from the French Broad (Jordan and Brayton, 1878). Cumberland River near Nashville (Gilbert and Swain, 1884, collectors). Watauga River near Elizabethton, Tenn., French Broad River near Hot Springs, N. C., and South Fork of the Swannanoa (Hat Creek) near Black Mountain, N. C. (Jordan, 1889). Rolling Fork of Salt River near Booth, Big Barren River near Bowling Green, Green River and Pitman Creek near Greensburg; and Cumberland River near Barbourville, Ky. (Woolman, 1892). Smith Fork near Lancaster, Tenn. (Kirsch, 1893). Falls of the Ohio (Evermann, 1902). Clinch River at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

18. **Noturus flavus** Rafinesque. (231.) Stone cat; little yellow cat.

Falls of the Ohio (Rafinesque 1818c, type, and 1820). Ohio River (Rafinesque 1819, as *Noturus luteus*). Tennessee River near Florence (Gilbert and Swain, collectors, 1884). Triplet Creek near Farmer, Ky. (Woolman, 1892). Smith Fork near Lancaster, and Obeys River and Eagle Creek near Olympus, Tenn. (Kirsch, 1893).

19. **Schilbeodes gyrinus** (Mitchill). (232.) Mad tom.

Mayfield Creek near Hickory Grove, Rough Creek near Hartford, and Bayou de Chien near Moscow, Ky. (Woolman, 1892, as *Noturus gyrinus*).

20. **Schilbeodes eleutherus** (Jordan). (239.) Mad tom.

Big Pigeon River, Cocke County, Tenn. (Jordan and Brayton, 1877, type, and Jordan and Brayton, 1878, as *Noturus eleutherus*). French Broad River (Jordan, 1878, as *Noturus eleutherus*). Hines Creek, Clinton County, Ky. (Gilbert and Swain, 1884, collectors). French Broad River near Hot Springs, N. C. (Jordan, 1889). Green River near Greensburg, Ky. (Woolman, 1892, as *Noturus eleutherus*). Clinch River at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

21. **Schilbeodes miurus** (Jordan). (240.) Mad tom.

Clinch River near Clinton, Tenn. (Gilbert and Swain, collectors, 1884). North Fork of Holston River near Saltville, Va. (Jordan, 1889, as *Noturus miurus*). Rolling Fork of Salt River near Booth, New Haven, and New Market, Rough Creek near Hartford, Big Barren River near Bowling Green, Little Barren River near Osceola, Pitman Creek near Greenburg, Mayfield, Creek near Hickory Grove, Horse Creek near Garratsville, Middle Fork of Kentucky River near Hyden, Blaine Creek near Catalpa, and Little Sandy River near its mouth, Ky. (Woolman, 1892, as *Noturus miurus*). Clinch River at Walkers Ford, Tenn., Tennessee River near Knoxville, and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

22. **Ictiobus cyprinella** (Cuvier and Valenciennes). (270.) Common buffalo.

Indian Creek, Clinton County, Ky. (Kirsch, 1892).

23. **Ictiobus urus** (Agassiz). (271.) Mongrel buffalo.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Carpiodes urus*, type; Jordan, 1878, and Jordan and Brayton, 1878, as *Bubalichthys urus*).

24. **Ictiobus bubalus** (Rafinesque). (273.) Smallmouth buffalo.

Ohio River (Rafinesque, 1819, as *Amblodon bubalus*, type, and Rafinesque, 1820a, as *Catostomus bubalus*). Big Barren River near Bowling Green, lower Cumberland River near Kuttawa, Ky., Powell River near Cumberland Gap, Tenn., Bayou de Chien near Moscow, Ky. (Woolman, 1892). Falls of the Ohio (Evermann, 1902).

25. **Carpiodes carpio** (Rafinesque). (274.) Carp sucker.

Falls of the Ohio (Rafinesque, 1820a, as *Catostomus carpio*, type). Tennessee River (Cope, 1877, and Jordan, 1878, as *Carpiodes bison*). Lower Tennessee River (Jordan and Brayton, 1878, as *Carpiodes bison*). Rolling Fork of Salt River near Booth, and Tradewater River near Dawson Springs, Ky. (Woolman, 1892). Falls of the Ohio (Evermann, 1902).

26. **Carpiodes difformis** Cope. (275.) Small carp sucker.

Cumberland River at Nashville (Jordan and Brayton, 1878, and Jordan, 1878, as *Carpiodes cutisanserinus*). Cumberland River near Kuttawa, Obion River near Cypress, and Big Sandy River near its mouth (Woolman, 1892). Caney Fork River and Smith Fork near Lancaster, Tenn., and Willis Creek at its mouth in Clinton County, Ky. (Kirsch, 1893, as *Ictiobus difformis*).

27. **Carpiodes velifer** (Rafinesque). (277.) Quillback.

Tennessee River near Paducah, Mayfield Creek near Hickory Grove, Obion River near Cypress, Redbird Creek near Big Creek, Middle Fork of Kentucky River near Hyden, North Fork Kentucky River near Hazard, Robinson Creek near Robinson, Levisa Fork of Big Sandy River near Pikeville, John and Coon Creeks near Zebulon, and Little Sandy River (Woolman, 1892). Falls of the Ohio (Evermann, 1902).

28. **Cycleptus elongatus** (Le Sueur). (279.) Blackhorse.

Ohio River (Rafinesque, 1819, as *Cycleptus nigrescens* and (?)*Amblodon niger*, types). Ohio River as far as Pittsburgh (Rafinesque, 1820a, as *Cycleptus elongatus*). Ohio River (Rafinesque, 1820a, as *Cycleptus nigrescens*). Cumberland River near Nashville (Jordan and Brayton, 1878). Lower Cumberland River near Kuttawa, Ky. (Woolman, 1892). Falls of the Ohio (Evermann, 1902).

29. **Catostomus commersonii** (Lacépède). (300.) White sucker; common sucker.

All streams and ponds in Kentucky (Rafinesque, 1820a, as *Catostomus flexuosus*, type). Tennessee River near Huntsville (Agassiz, 1854, as *Catostomus communis*). Holston River (Cope, 1869, as *Catostomus communis*). Clinch and French Broad Rivers (Cope, 1877, as *Catostomus teres*). Very common in the Cumberland (Jordan and Brayton, 1878). Clear Fork of the Cumberland near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Catostomus teres*). Generally abundant in the Tennessee Basin, South Fork of Holston River near Holstein Mills, Va., Middle Fork of Holston near Marion and Glade Spring, Va., Beaver Creek near Bristol, and Watauga River near Elizabethton, Tenn., Swannanoa River near Asheville, N. C., South Fork (Hat Creek) of Swannanoa River near Black Mountain station, and Spring Creek near Hot Springs, N. C. (Jordan, 1889, as *Catostomus teres*). Rockcastle River above the mouth of the Little Rockcastle and near Livingston, Smoky Fork of Richland Creek near its mouth, Clear Fork of the Cumberland, and Wolf and Briar Creeks near Pleasant View, Whitley County, Mayfield Creek near Hickory Grove, Hector Creek near Big Creek, Goose Creek near Garratsville, and Bull Creek near Hyden, Ky. (Woolman, 1892). Wolf River and Indian and Willis Creeks, Clinton County, Ky. (Kirsch, 1892, as *Catostomus teres*). Spring Creek near Spring Creek station, Ky. (Kirsch, 1893, as *Catostomus teres*). Falls of the Ohio (Evermann, 1902). Ball Creek near Tazewell; Arnwine Spring Creek near Mount Verd, Eastaunaula Creek near Athens, and Roaring Fork near Greenville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

30. **Hypentelium nigricans** (Le Sueur). (304.) Hog sucker.

Falls of the Ohio (Rafinesque, 1818b, as *Exoglossum (Hypentelium) macropterum*, type). Below the Falls of the Ohio (Rafinesque, 1820a, as *Catostomus xanthopterus*, type). Tennessee River near Huntsville (Agassiz, 1854). Holston River (Cope, 1869). Powell River, Tenn. (Jordan, 1876). Clinch and French Broad Rivers (Cope, 1877). Common in the Cumberland (Jordan and Brayton, 1878). Clear Fork of the Cumberland near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883). South Fork of Holston at Holstein Mills, Va., Middle Fork of Holston at Marion and Glade Spring, Va., Beaver Creek near Bristol, Tenn., Watauga and Doe Rivers near Elizabethton, Tenn., Swannanoa River at Asheville, N. C., South Fork (Hat Creek) of the Swannanoa at Black Mountain station, N. C., and Spring Creek at Hot Springs, N. C. (Jordan, 1889). Rolling Fork of Salt River near Booth, New Haven, and New Market, Rough Creek near Hartford, Big Barren River near Bowling Green, Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River and Pitman Creek near Greensburg, Tradewater River at Dawson Springs, Cumberland River near Kuttawa, Clear Creek near Wildie, Little Rockcastle River near Livingston, Rockcastle River near Hazel Patch and Livingston, Cumberland River at Barbourville and Pineville, Richland Creek near Barbourville, Smoky Fork of Richland Creek near its mouth, Straight Creek near Pineville, Indian Creek and Albany

Branch in Clinton County, Clear Fork of the Cumberland, Wolf Creek, and Briar Creek near Pleasant View, Powell River near Cumberland Gap, Mayfield Creek near Hickory Grove, Horse Creek near Garratsville, Hector, Redbird (South Fork of the Kentucky), and Big Creeks near Big Creek, Bull Creek, Middle Fork of the Kentucky, and Cutshin Creek near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, and Left Troublesome Creek near Hindman, Right Fork of Beaver Creek near Lackey, Robinson and Shelby Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, Coon Creek near Zebulon, and Blaine Creek near Catalpa, and Triplet Creek near Farmer, Ky. (Woolman, 1892). Indian, Willis, Spring, and Albany Creeks, Clinton County, Ky. (Kirsch, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Spring Creek Station, Caney Fork River near Lancaster, Smith Fork near Lancaster, Roaring River near Windle, Obeys River and Eagle Creek near Olympus, and Wolf River near Byrdstown, Tenn., Little South Fork of Cumberland River 8 miles above its mouth, Rock Creek near Whitley station, Ky., Willis Creek at its mouth, Cumberland County, Ky., Beaver Creek, Wayne County, Canada Creek, New River at New River station, Otter Creek between Monticello and Albany, Big South Fork of the Cumberland near mouth of Rock Creek, and Brimstone Creek near New River station, Ky. (Kirsch, 1893). Ball Creek near Tazewell, Tennessee River near Knoxville, Eastaunaula Creek near Athens, Arnwine Spring near Mount Verd, and Tellico River at Tellico Plains, Tenn., Chickamauga Creek at Lee & Gordon's mill, Ga., Indian Creek near Cumberland Gap, Clinch River at Walkers Ford, and Roaring River near Greenville, Tenn. (Evermann, Scovell and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

31. **Erimyzon sucetta** (Lacépède). (313.) Chub sucker.

French Broad River (Jordan, 1876). Cumberland and Rockcastle Rivers, Ky. (Jordan, 1876). Clinch River (Jordan and Brayton, 1878). Cumberland River near Nashville and Rockcastle River near Livingston, Ky. (Jordan and Brayton, 1878). Cumberland River (Jordan, 1878a; collector, Prof. A. Winchell). Florence, Ala. (Gilbert and Swain, 1884, collectors).

32. **Erimyzon sucetta oblongus** Mitchill. (313a.) Northern chub sucker.

Tradewater River near Dawson, Rockcastle River near Livingston, and Mayfield Creek near Hickory Grove, Ky. (Woolman, 1892).

33. **Minytrema melanops** (Rafinesque). (314.) Spotted sucker.

Ohio River (Rafinesque, 1820a, as *Catostomus melanops*, type). Tennessee River near Huntsville (Agassiz, 1854, as *Catostomus melanops*, and Jordan and Brayton, 1878). Tennessee River (Jordan, 1878). Cumberland River near Nashville (Jordan and Brayton, 1878). Beaver Creek near Glasgow, Ky. (Woolman, 1892).

34. **Moxostoma anisurum** (Rafinesque). (316.) White-nosed sucker.

All over the Ohio and the larger streams as far as Pittsburgh (Rafinesque, 1820a, as *Catostomus anisurus* type). Clinch River and Chickamauga Creek (Jordan and Brayton, 1878, and Jordan, 1878a, as *Myxostoma velatum*). Clear Fork of the Cumberland near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Moxostoma velatum*). Richland Creek, Pulaski County, Tenn. (Gilbert and Swain, 1884, collectors). Little Sandy River, Ky. (Gilbert and Henshall, 1888, collectors; and Woolman, 1892). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan, 1883, collector; and Woolman, 1892).

35. **Moxostoma aureolum** (Le Sueur). (325.) Common redhorse.

Ohio River (Rafinesque, 1818, as *Catostomus erythrurus*, type). Tennessee River (Rafinesque, 1820, as *Catostomus erythrurus*). Cumberland River (Rafinesque, 1820, as *Catostomus erythrurus*). Kentucky River (Rafinesque, 1820a, as *Catostomus erythrurus*). Ohio River (Rafinesque, 1820a, as *Rutilus melanurus*, type). Tennessee River near Huntsville (Agassiz, 1854, as *Catostomus Duquesnii*). Holston River (Cope, 1869, as *Teretulus Duquesnii*). French Broad River and Rockcastle River (Jordan, 1876, as *Moxostoma duquesnei*). Holston River (Cope, 1877, as *Ptychostomus erythrurus*). Common in the Cumberland (Jordan and Brayton, 1878, and Jordan, 1878a, as *Myxostoma macrolepidotum duquesnii*). Holston, Clinch, French Broad, and Chickamauga Rivers (Jordan and Brayton, 1878, as *Myxostoma macrolepidotum duquesnii*). Clear Fork of the Cumberland near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Moxostoma macrolepidotum duquesnii*). Watauga River near Elizabethton, Tenn., and French Broad River and Spring Creek near Hot Springs, N. C. (Jordan, 1889, as *Moxostoma duquesnei*). Duck River near Columbia, Tenn. (Gilbert and Swain, 1884, collectors). Middle Fork of

Holston River near Marion and Glade Spring, Va., North Fork of Holston River near Saltville, Va., Beaver Creek near Bristol, Tenn., Rolling Fork of Salt River near Booth, New Haven, and New Market, Pond Creek near Rockport, Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, upper Green River and Pitman Creek near Greensburg, Tradewater River near Dawson, lower Cumberland River near Kuttawa, Clear Creek near Wildie, Little Rockcastle River near Livingston, Rockcastle River just above the mouth of Little Rockcastle River and near Livingston, Cumberland River and Richland Creek near Barbourville, Smoky Fork of Richland Creek above its mouth, Cumberland River and Straight Creek near Pineville, Clear Fork of the Cumberland, Wolf Creek, and Briar Creek near Pleasant View, Whitley County, Tennessee River near Paducah, Ky., Powell River near Cumberland Gap, Tenn., Mayfield Creek near Hickory Grove, Bayou de Chien near Moscow, Horse and Goose Creeks near Garratsville, Redbird Creek near Big Creek, Bull and Cutshin Creeks and Middle Fork of the Kentucky near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Beaver Creek near Lackey, Robinson Creek near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, Coon Creek near Zebulon, Blaine Creek near Catalpa, Licking River and Triplet Creek near Farmer, and Little Sandy River, Ky. (Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek railway station, Caney Fork near Lancaster, Obeys River and Eagle Creek near Olympus, and Wolf River near Byrdstown, Tenn., Cumberland River in Cumberland County, Willis Creek at its mouth in Cumberland County, Beaver Creek in Wayne County, Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Big South Fork of the Cumberland near Whitley station, Canada Creek, and Rockcastle River, Ky. (Kirsch, 1893). Falls of the Ohio (Evermann, 1902).

36. **Moxostoma breviceps** (Cope). (330.) Short-headed redhorse.

Little Sandy River (Gilbert and Henshall, 1888, collectors; and Woolman, 1892).

37. **Placopharynx duquesnii** (Le Sueur). (335.) Big-jawed sucker.

Ohio River as far as Pittsburgh (Rafinesque, 1820a, as *Catostomus duquesni*). French Broad River at Alexanders, N. C. (Evermann, July, 1878, collector).

38. **Lagochila lacera** Jordan and Brayton. (336.) Hare-lip sucker.

Chickamauga Creek near Ringgold, Ga. (Jordan and Brayton, 1877, type). Elk River near Estill Springs, Tenn. (Jordan and Brayton, 1877 and 1878). Chickamauga Creek and Elk River (Jordan, 1878a, as *Quassilabia lacera*). Clinch River, Tenn. (Jordan and Gilbert, 1882). Chickamauga Creek and Elk River (Jordan, 1882). North Fork of Holston River near Saltville, Va. (Jordan, 1889). Clear Creek near Wildie, and Rockcastle River near Livingston, Ky. (Woolman, 1892). West Fork of Stone River near Murfreesboro, Little South Fork of the Cumberland near mouth of Canada Creek, and Canada Creek, Tenn. (Kirsch, 1893).

39. **Campostoma anomalum** (Rafinesque). (339.) Stone-roller; rot-gut minnow.

Licking River (Rafinesque, 1820, as *Rutilus anomalus*, type). Falls of the Ohio (Rafinesque, 1820a, as *Catostomus melanotus*, type). Licking River, etc. (Rafinesque, 1820a, as *Rutilus anomalus*). Spring Branch near Huntsville (Agassiz, 1854, as *Chondrostoma prolixum*). Holston River, Va. (Günther, 1868, as *Campostoma dubium*). Holston River, Va. (Cope, 1868). Tributaries of the Holston (Cope, 1869). Cumberland and Rockcastle Rivers, Ky. (Jordan and Gilbert, 1876, collectors, and Jordan, 1876). French Broad and Powell Rivers, Tenn. (Jordan, 1876). French Broad and Clinch Rivers (Cope, 1877). Cumberland River (Cope, 1877). Cumberland River at Cumberland Falls (Evermann, collector, June, 1878). Abundant in the Cumberland River (Jordan and Brayton, 1878). In the clear pools of the Swannanoa at the foot of Black Mountain, extremely abundant (Jordan and Brayton, 1878, as *Campostoma anomalum prolixum*). Clear Fork of the Cumberland and Wolf and Briar Creeks, near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883). Rockcastle River near Livingston, Tennessee River near Florence, Clinch River near Clinton, Tenn., and Wolf Creek in Cocke County, Tenn. (Gilbert and Swain, collectors, 1884). Little Sandy River (Gilbert and Henshall, 1888, collectors). South Fork of the Holston at Holstein Mills, Va., Middle Fork of the Holston near Marion and Glade Spring, Va., North Fork of the Holston near Saltville, Va., Beaver Creek near Bristol and Watauga and Doe Rivers near Elizabethton, Tenn., Spring Creek near Hot Springs, Swannanoa River near Asheville, and South Fork of the Swannanoa at Black Mountain station, N. C. (Jordan, 1889). Tennessee River near Whiteside, Tenn. (Henshall, 1889). Willis, Spring, Smith, and Albany Creeks in Clinton County, Ky.

(Kirsch, 1892). Rolling Fork of Salt River near Booth, Rough Creek at Hartford, Big Barren River at Bowling Green, Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren and Green Rivers and Pitman Creek near Greensburg, Tradewater River near Dawson, Lower Cumberland River near Kuttawa, Clear Creek near Wildie, Rockcastle River near mouth of Little Rockcastle River, Cumberland River near Barbourville, Richland Creek near Barbourville, Straight Creek near Pineville, Smith Creek, Spring Creek, Albany Branch, and pond near Albany, Clinton County, Ky., Clear Fork of the Cumberland, Wolf Creek and Briar Creek near Pleasant View, Whitley County, Ky., Powell River near Cumberland Gap, Goose Creek near Garratsville, Hector Creek, Redbird Creek, and Big Creek near Big Creek post office, Bull Creek, Middle Fork of the Kentucky, and Cutshin Creek near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Fork of Beaver Creek near Lackey, Robinson and Shelby Creeks near Robinson, Island Creek near Pikeville, Little Fork of Big Sandy River near Pikeville, John and Coon Creeks near Zebulon, and Licking River and Triplet Creek near Farmer, Ky. (Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek railway station, Round Lick Creek near Watertown, Smith Fork near Lancaster, Roaring River near Windle, Eagle Creek near Olympus, Wolf River near Byrdstown, Beaver Creek in Wayne County, Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, Rock Creek near Whitley station, New River, Ky., and Brimstone Creek near New River railway station (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, Roaring Fork near Greenville, Eastaunaula Creek near Athens, Tellico River at Tellico Plains, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

40. **Chrosomus erythrogaster** Rafinesque. (345.) Red-bellied dace.

Kentucky River (Rafinesque, 1820a, as *Luxilus* or *Chrosomus erythrogaster*, type). Tennessee River near Huntsville (Agassiz, 1854; and Jordan and Brayton, 1878). Rockcastle and Cumberland Rivers (Jordan, 1876). Tennessee River and tributaries of Rockcastle River (Jordan and Brayton, 1878). Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883). Florence, Ala., and Clinch River near Clinton, Tenn. (Gilbert and Swain, 1884, collectors). Tennessee River at Whiteside, Tenn. (Henshall, 1889). Indian, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892). Rockcastle River near Livingston, Ky. (Jordan and Gilbert, 1876, collectors; Woolman, 1892). Smith Creek, Spring Creek, Albany Branch and Indian Creek (Kirsch, 1889 and 1890, collector; Woolman, 1892). Tennessee River near Paducah, Clear Fork of the Cumberland, Wolf Creek, and Briar Creek near Pleasant View, Whitley County, Ky. (Jordan, 1883, collector; Woolman, 1892). Roaring River near Windle, Spring Creek at Springcreek station, Tenn., and Beaver Creek in Wayne County, Ky. (Kirsch, 1893). Roaring Fork near Greenville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

41. **Hybognathus nuchale** Agassiz. (353.) Silvery minnow; gudgeon.

Tennessee River (Gilbert and Swain, 1884, collectors). Pond Creek near Rockport, Rough Creek at Hartford, Beaver Creek near Glasgow, lower Cumberland River near Kuttawa, Mayfield Creek at Hickory Grove, Obion River near Cypress, Bayou de Chien near Moscow, and mouth of the Big Sandy River (Gilbert and Henshall, 1888, collectors). Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Smith Fork near Lancaster, Tenn. (Kirsch, 1893, as *Hybognathus nuchalis*).

42. **Pimephales promelas** Rafinesque. (362.) Black-head minnow.

Pond near Lexington, Ky. (Rafinesque, 1820a, type). Tributaries of the Cumberland above Nashville (Prof. A. Winchell, collector; Jordan and Brayton, 1878).

43. **Pimephales notatus** (Rafinesque). (363.) Blunt-nosed minnow.

Ohio River (Rafinesque, 1820a, as *Minnilus notatus*, type). Chickamauga Creek near Ringgold, Ga. (Jordan and Brayton, 1878, as *Hyborhynchus notatus*). Rockcastle River, Ky. (Jordan, 1876, as *Hyborhynchus notatus*). Abundant everywhere in the Cumberland (Jordan and Brayton, 1878, as *Hyborhynchus notatus*). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Hyborhynchus notatus*). Rolling Fork, Ky. (Gilbert and Swain, 1884, collectors). Indian, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892). Rolling Fork of Salt River near Booth and New Haven, Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Tradewater River near Dawson, lower Cumberland River near Kuttawa, Clear Creek near Windle, Rockcastle River above the mouth of Little Rockcastle River, Cumberland River near Barbourville, Indian Creek in Clinton County, Clear Fork of the Cumberland, Wolf and Briar Creeks near Pleasant View, Whitley County, Ky., Powell River near Cumberland Gap, Tenn., Mayfield Creek at Hickory Grove, Ky., Obion River near Cypress, Bayou de Chien near Moscow, Horse Creek and Goose Creek near Garratsville, Hector Creek and Redbird Creek (South Fork of the Kentucky) and Big Creek near Big Creek post office, Bull Creek, Middle Fork, and Cutshin Creek near Hyden, North Fork of the Kentucky River and Lot Creek near Hazard, Troublesome Creek near Hazard, Left Troublesome Creek at Hindman, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, and Blaine Creek near Catalpa, Triplet Creek and Licking River near Farmer, Ky., and Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Spring Creek railway station, Ky., Round Lick Creek at Watertown, Smith Fork near Lancaster, and Wolf River near Byrdstown, Beaver Creek in Wayne County, Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, and Canada Creek near its mouth (Kirsch, 1893). Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

44. **Semotilus atromaculatus** (Mitchill). (368.) Horned dace; creek chub.

In the Kentucky and several other rivers (Rafinesque, 1820a, as *Semotilus dorsalis*, type). Creeks of Kentucky, etc. (Rafinesque, 1820a, as *Senotilus* [*Semotilus*] *cephalus*, type). Kentucky River near Estill (Rafinesque, 1820a, as *Senotilus diplemia*, type). Powell, French Broad, Rockcastle, and Cumberland Rivers (Jordan, 1876, as *Semotilus corporalis*). Tributaries of Clinch and French Broad Rivers, chiefly in small mountain streams, and Rockcastle River at Livingston, Ky. (Jordan and Brayton, 1878, as *Semotilus corporalis*). Rolling Fork of Salt River near New Haven, Drake Creek near Bowling Green, Beaver Creek near Glasgow, Cumberland River and Richland Creek near Barbourville, Smoky Fork near its mouth, and Rockcastle River near Livingston (Gilbert, 1884, collector). Rockcastle River near Livingston (Jordan and Gilbert, 1876, collectors). Spring Creek, Albany Branch, and pond near Albany (Kirsch, 1889–90, collector). Mayfield Creek near Hickory Grove, Goose, Redbird, and Left Troublesome Creeks, an old bayou of Bull Creek, and Blaine Creek near Catalpa (Woolman, 1892). Round Lick Creek at Watertown, Roaring River near Windle, Spring Creek and its tributaries near Springcreek station, Tenn., Beaver Creek in Wayne County, Ky., and Canada Creek near its mouth (Kirsch, 1893). Ball Creek near Tazewell and Eastaunaula Creek and Norvel Spring Branch near Athens, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

45. **Leuciscus vandoisulus** Cuvier and Valenciennes. (390.) Shiner.

Elk River near Estill Springs and Stone River near Murfreesboro, Tenn. (Jordan and Brayton, 1878, as *Gila estor*, type). Tennessee and Cumberland Rivers (Jordan, 1878, as *Gila estor*).

46. **Leuciscus flammeus** (Jordan and Gilbert). (397.) Red-bellied minnow.

Holston River near Knoxville (Cope, 1870, as *Hemitremia vittata*, type, and Jordan and Brayton, 1878). Big Laurel River, Ky. (Jordan, 1876). Abundant in Big Laurel River, Laurel County, Ky. (Jordan and Brayton, 1878, as *Hemitremia vittata*). Cumberland and Tennessee Rivers (Jordan, 1878, as *Hemitremia vittata*). Elk River at Estill Springs, Tenn. (Jordan and Gilbert in Jordan, 1878, type, and Jordan and Brayton, 1878, as *Phoxinus flammeus*). Clear Fork and Wolf Creek near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Hemitremia vittata*). Tennessee River near Huntsville (Gilbert and Swain, 1884, collectors).

47. **Opsopœodus emiliæ** Hay. (407.) Emily's minnow.

Cumberland River near Kuttawa, Mayfield Creek near Hickory Grove, and Bayou de Chien near Moscow, Ky. (Woolman, 1892).

48. **Opsopœodus bollmani Gilbert.** (409.) Bollman's minnow.

Obion River near Cypress, Ky. (Woolman, 1892).

49. **Abramis crysoleucas** (Mitchill). (410.) Golden shiner; roach.

Falls of the Ohio (Rafinesque, 1819, as *Notemigonus auratus*, type). Kentucky River (Rafinesque, 1820, as *Notemigonus auratus*). Common in still, sluggish waters of the Cumberland and Tennessee

Basins (Jordan and Brayton, 1878, as *Notemigonus chrysoleucus*). Mayfield Creek near Hickory Grove (Woolman, 1892, as *Notemigonus chrysoleucus*).

50. **Cliola vigilax** (Baird and Girard). (414.) Bull-head minnow.

Clinch River near Clinton, Stone River near Nashville, and Richland Creek near Pulaski, Tenn. (Gilbert and Swain, 1884, collectors). Rolling Fork of Salt River near Booth, lower Cumberland River near Kuttawa, Blaine Creek near Catalpa, and Little Sandy River, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Ball Creek near Tazewell, Clinch River at Walkers Ford, Tennessee River near Knoxville, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

51. **Notropis blennius** (Girard). (423.) Straw-colored minnow.

Kentucky River (Rafinesque, 1820a, as *Minnilus microstomus*, type). Cumberland River (U. S. N. M.). Cumberland River near Nashville (Jordan and Brayton, 1878, as *Photogenis analostanus*). Tributaries of Clinch River (Jordan and Brayton, 1878, as *Alburnops microstomus*). South Fork of the Cumberland (*fide* Cope, Jordan and Brayton, 1878, as *Alburnops microstomus*). North Fork of the Holston near Saltville, Va., and Doe River near Elizabethton, Tenn. (Jordan, 1889, as *Notropis microstomus*). Rolling Fork of Salt River near Booth and New Haven, Green River near Greensburg, Tradewater River near Dawson and Rockcastle River near Livingston (Jordan and Gilbert, 1876, collectors, and Gilbert, 1884, collector). Rockcastle River near Livingston, Cumberland River near Barbourville, Straight Creek near Pineville, and Smith Creek and Albany Branch in Clinton County, Ky. (Kirsch, 1889–90, collector). Powell River near Cumberland Gap, Obion River near Cypress, Bull Creek, Middle Fork and Cutshin Creek near Hyden, North Fork of the Kentucky near Hazard, Troublesome Creek near Dwarf, Redbird Creek (South Fork of the Kentucky) near Big Creek, Beaver Creek near Lackey, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Triplet Creek near Farmer, and Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892, as *Notropis deliciosus*). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, and Roaring Fork near Greenville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

52. **Notropis spectrunculus** (Cope). (431.)

Bear Creek, a tributary of the Middle Fork of the Holston in Smyth County, Va., also probably the adjacent tributaries of the same stream—the Hungrysmother and Chilohoway Creeks (Cope, 1869, as *Hybopsis spectrunculus*, type). Holston and French Broad Rivers (Jordan and Brayton, 1878, as *Alburnops spectrunculus*). Tennessee River near Florence and Wolf Creek in Cocke County, Tenn. (Gilbert and Swain, 1884, collectors). Middle Fork of the Holston at Marion and Glade Spring, South Fork of the Holston at Holstein Mills, Va., Spring Creek near Hot Springs, North Fork of the Swannanoa at Burnett's mills, and South Fork of the Swannanoa at Black Mountain station, N. C. (Jordan, 1889). Cumberland River near Barbourville, Redbird Creek (South Fork of the Kentucky) near Big Creek (?) (Woolman, 1892).

53. **Notropis shumardi** (Girard). (441.) Shumard's minnow.

West Fork of Stone River near Murfreesboro, and Wolf River near Byrdstown, Tenn. (Kirsch, 1893, as *Notropis boops*). Indian Creek near Cumberland Gap (Gurley, 1893, collector; and Evermann and Hildebrand, 1916).

54. **Notropis whipplii** (Girard). (463.) Silver-fin; satin-fin; blue minnow.

Cumberland River near Nashville (Jordan and Brayton, 1878, as *Photogenis analostanus*). Tennessee River near Florence, Ala., and Rockcastle River, Ky. (Gilbert and Swain, 1884, collectors). Indian Creek in Clinton County, Ky. (Kirsch, 1892). Rolling Fork of Salt River near Booth (Woolman, 1892), and New Market and New Haven, Ky. (Gilbert and Swain, 1884, collectors; Woolman, 1892). Pond Creek near Rockport, Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River and Pitman Creek near Greensburg, lower Cumberland River near Kuttawa, Clear Creek near Wildie, Little Rockcastle River near Livingston, and Rockcastle River at Livingston (Gilbert, 1884, collector). Near mouth of the Little Rockcastle and near Livingston, Cumberland River and Richland Creek near Barbourville, Smoky Fork of Richland Creek near its mouth, Straight Creek near Pineville, Tennessee River near Paducah, Powell River near Cumberland Gap, Bayou de Chien near Moscow, Horse and Goose Creeks near Garratsville, Hector Creek near Big Creek post office, Redbird Creek (South Fork of the Kentucky), Bull Creek, Cutshin Creek, and Middle Fork of the Kentucky near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Beaver Fork of the Big Sandy near Lackey, Shelby and Robinson Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, and Blaine Creek near Catalpa, Licking River and Triplet Creek near Farmer, and Little Sandy River near its mouth (Gilbert and Henshall, 1884, collectors; Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Springcreek station, Caney Fork and Smith Fork near Lancaster, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Willis Creek at its mouth, Beaver Creek in Wayne County, Ky., Otter Creek between Monticello and Albany, Big South Fork of the Cumberland near mouth of Rock Creek, Rock Creek west of Whitley station, and New River and Brimstone Creek near New River railway station, Ky. (Kirsch, 1893).

55. **Notropis galacturus** (Cope). (465.)

Abundant in the tributaries of the Holston in Virginia (Cope, 1867, as *Hypsilepis galacturus*, type). Streams of the Holston (Cope, 1869, as *Hypsilepis galacturus*). French Broad and Powell Rivers, Tenn. (Jordan, 1876, as *Hypsilepis galacturus*). Tennessee River (Jordan, 1878; and Jordan and Brayton, 1878). Cumberland River (Jordan, 1878, as *Luxilus galacturus;* and Jordan, 1888, as *Photogenis galacturus*). Clinch River near Clinton, Wolf River in Cocke County, Harpeth River near Franklin, and Duck River near Columbia, Tenn. (Gilbert and Swain, 1884, collectors). Spring Creek near Hot Springs, Swannanoa River near Asheville, South Fork of the Swannanoa at Black Mountain station, N. C., South Fork of the Holston near Holstein Mills, Middle Fork of the Holston near Glade Spring, North Fork of the Holston near Saltville, Va., Beaver Creek near Bristol and Watauga and Doe Rivers near Elizabethton, Tenn. (Jordan, 1889). Indian, Willis, Spring, and Smith Creeks in Clinton County, Ky. (Kirsch, 1892). Rockcastle River near Livingston (Jordan and Gilbert, 1876, collectors). Clear Creek near Wildie, Richland Creek near Barbourville, Spring Creek, Smith Creek, Albany Branch, and Indian Creek in Clinton County, Ky. (Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek station, Smith Fork near Lancaster, Roaring Fork near Windle, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Willis Creek at its mouth, Beaver Creek in Wayne County, Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Rock Creek near Whitley station, and New River near New River station, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Clinch River at Walkers Ford, Ball Creek near Tazewell, Tennessee River near Knoxville. Roaring Fork near Greenville, Eastaunaula Creek near Athens, and Tellico River at Tellico Plains, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

56. **Notropis cornutus** (Mitchill). (471.) Golden shiner; red-fin dace.

Cumberland River (Rafinesque, 1820, as *Luxilus chrysocephalus*, type). Ohio, Kentucky, Cumberland, and Green Rivers, etc. (Rafinesque, 1820a, as *Luxilus chrysocephalus*, type). Streams of Kentucky (Rafinesque, 1820a, as *Rutilus plargyrus*, type). Ohio River (Rafinesque, 1820a, as *Luxilus interruptus*, type). Tennessee River at Florence (Storer, 1845, as *Leuciscus obesus*, type). Tennessee River near Huntsville (Agassiz, 1854, as *Stilbe obesus* and *Hypsolepis gibbosus*). Tennessee River (Cope, 1867, as *Hypsolepis cornutus*). Holston River, Va. (Cope, 1867 and 1869, as *Hypsolepis cornutus frontalis*). Powell and French Broad Rivers (Jordan, 1876). "Exceedingly abundant everywhere" in Kentucky and Tennessee (Jordan and Brayton, 1878, as *Luxilus cornutus*). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Minnilus cornutus*). Chickamauga Creek near Ringgold, Ga., Elk River and tributaries near Estill Springs, Tenn., Powell River, Indian Creek, and Station Creek near Cumberland Gap, French Broad River at Newport and Big Pigeon River at Clifton, Tenn., and Swannanoa River at foot of Black Mountain, N. C. (Jordan and Brayton, 1878, as *Luxilus cornutus*). South Fork of the Holston at Holstein Mills, Middle Fork of the Holston near Glade Spring, and North Fork of the Holston near Saltville, Va., Beaver Creek near Bristol, and Watauga and Doe Rivers near Elizabethton, Tenn. (Jordan, 1889, as *Notropis megalops*). Indian, Willis, Spring, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892). Rolling Fork of Salt River near Booth, New Haven, and New Market, Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River and Pitman Creek near Greensburg, Tradewater River near Dawson Springs, Cumberland River near Kuttawa, Clear Creek near Wildie, Little

Rockcastle River and Rockcastle River near Livingston, Cumberland River and Richland Creek near Barbourville, Smoky Fork of Richland Creek near its mouth, Straight Creek near Pineville, Smith and Spring Creeks, Albany Branch and a pond near Albany (Kirsch, 1889–90, collector). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan, 1883, collector). Powell River near Cumberland Gap, Mayfield Creek near Hickory Grove, Obion River near Cypress, Goose Creek near Garratsville, Hector Creek near Big Creek post office, Redbird Creek (South Fork of the Kentucky), Bull Creek, Cutskin Creek, and Middle Fork of the Kentucky near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, and Left Troublesome Creek near Hindman (Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Springcreek station, Round Lick Creek at Watertown, Smith Fork near Lancaster, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., and Willis Creek at its mouth, Beaver Creek in Wayne County, Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near the mouth of Canada Creek, and Canada Creek at its mouth, Ky. (Kirsch, 1893, as *Notropis megalops*). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, Roaring Fork and Nolichucky River near Greenville, Eastaunaula Creek near Athens, Arnwine Spring Creek near Mount Verd, and Tellico River at Tellico Plains, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

57. **Notropis lacertosus** (Cope). (474.)

Bear Creek, a tributary of the Middle Fork of the Holston in Virginia (Cope, 1869, as *Hybopsis lacertosus*, type). Holston River (Jordan and Brayton, 1878, as *Hydrophlox lacertosus*). Tennessee River (Jordan, 1878, as *Luxilus lacertosus* and *Alburnops lacertosus*). South Fork of the Holston at Holstein Mills and North Fork of the Holston near Saltville, Va. (Jordan, 1889).

58. **Notropis coccogenis** (Cope). (476.)

"Abundant in the clear and often rapid creeks that flow into the North and Middle Forks of the Holston in Virginia" (Cope, 1867, as *Hypsilepis coccogenis*, type). Streams of the Holston (Cope, 1869, as *Hypsilepis coccogenis*). Powell River, Tenn. (Jordan, 1876, as *Luxilus coccogenis*). Chickamauga Creek at Ringgold, Ga., Elk River and tributaries near Estill Springs; Powell River, Indian Creek and Station Creek near Cumberland Gap, French Broad River at Newport, and Big Pigeon River at Clifton, Tenn., and Swannanoa River at foot of Black Mountain, N. C. (Jordan and Brayton, 1878, as *Luxilus coccogenis*). Tennessee River (Jordan, 1878, as *Luxilus coccogenis*). Tennessee River at Florence, and Wolf Creek in Cocke County, Tenn. (Gilbert and Swain, 1884, collectors). Spring Creek near Hot Springs, Swannanoa River near Asheville, North Fork of the Swannanoa at Burnett's mill, N. C., Middle Fork of the Holston near Marion and Glade Spring, South Fork of the Holston at Holstein Mills, North Fork of the Holston near Saltville, Va., Beaver Creek near Bristol, and Watauga and Doe Rivers near Elizabethton, Tenn. (Jordan 1889). Robinson Creek near Robinson, Ky. (Woolman, 1892). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Arnwine Spring Creek near Mount Verd, Tellico River at Tellico Plains, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

59. **Notropis zonatus** (Agassiz). (477.)

Nolichucky River near Greenville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

60. **Notropis rubricroceus** (Cope). (479.) Red fallfish.

Bear Creek, a tributary of the Middle Fork of the Holston in Smyth County, Va., also probably the adjacent tributaries of the same stream—Hungrysmother and Chilohoway Creeks, also near the mouth of Tumbling Creek, a tributary of the North Fork of the Holston (Cope, 1869, as *Hybopsis rubricroceus*, type). Tributaries of the Holston (Jordan and Brayton, 1878, as *Hydrophlox rubricroceus*). Tennessee River (Jordan, 1878, as *Hybopsis rubricroceus*). Middle Fork of the Holston at Holstein Mills, Va., and Doe River near Elizabethton, Tenn. (Jordan, 1889). South Mouse Creek near Cleveland, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

61. **Notropis ariommus** (Cope). (489.)

Tennessee River near Florence (Gilbert and Swain, 1884, collectors). Watauga River near Elizabethton, Tenn. (Jordan, 1889). Rolling Fork, of Salt River near New Market, Ky. (Gilbert and Swain, 1884, collectors). Big Barren River near Bowling Green, Little Barren River at Osceola, Green River near Greensburg, Drake Creek near Bowling Green, Redbird Creek (South Fork of the Kentucky) near Big Creek, Middle Fork of the Kentucky near Hyden, and Levisa Fork of the Big Sandy near Pikeville (Woolman, 1892). Round Lick Creek at Watertown, Tenn., and Rock Creek near Whitley railroad station, Ky. (Kirsch, 1893).

62. **Notropis jejunus** (Forbes). (491.)

Cumberland River near Kuttawa, Obion River near Cypress, mouth of Big Sandy River and Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892).

63. **Notropis leuciodus** (Cope). (494.)

Tributaries of the Holston (Cope, 1867, as *Photogenis leuciodus*, type). North Fork of the Holston near Saltville, Va. (Cope, 1869, as *Photogenis leuciodus*). Holston and French Broad Rivers (Jordan and Brayton, 1878, as *Episema leucioda*). Tennessee River (Jordan, 1878, as *Cliola leucioda*). Swannanoa River near Asheville and French Broad River and Spring Creek near Hot Springs, N. C., Watauga and Doe Rivers near Elizabethton, Beaver Creek near Bristol, Tenn., South Fork of the Holston at Holstein Mills, Middle Fork of the Holston near Marion and Glade Spring, and North Fork of the Holston near Saltville, Va. (Jordan, 1889). Smith Creek in Clinton County, Ky. (Kirsch, 1892).

64. **Notropis telescopus** (Cope). (495.)

Abundant in all the rapid streams tributary to the Holston River in Virginia, very rare in the river itself (Cope, 1867, as *Photogenis telescopus*, type). Tributaries of the Holston (Cope, 1869, as *Photogenis telescopus*). Holston and French Broad Rivers, and Elk River near Estill Springs, Tenn. (Jordan and Brayton, 1878). Tennessee River, and Stone River near Murfreesboro (Jordan, 1878). Swannanoa River near Asheville, South Fork of the Swannanoa at Black Mountain railroad station, North Fork of the Swannanoa near Burnett's mill, and Spring Creek near Hot Springs, N. C., Watauga and Doe Rivers near Elizabethton, Tenn., South Fork of the Holston near Holstein Mills, Middle Fork of the Holston near Marion and Glade Spring, and North Fork of the Holston near Saltville, Va. (Jordan, 1889). Little Barren River near Osceola, and Indian Creek (Kirsch, 1889-90, collector; Woolman, 1892). Indian Creek in Clinton County, Ky. (Kirsch, 1892). West Fork of Stone River near Murfreesboro and Obeys River and Eagle Creek near Olympus, Tenn., Willis Creek at its mouth, Big South Fork of the Cumberland and Rock Creek near Whitley station, and Canada Creek in Wayne County, Ky.(Kirsch, 1893). Indian Creek near Cumberland Gap, and Tellico River at Tellico Plains, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

65. **Notropis stilbius** Jordan. (498.)

Ball Creek near Tazewell, Clinch River at Walkers Ford, Nolichucky River near Greenville, and Tellico River at Tellico Plains, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

66. **Notropis atherinoides** Rafinesque. (499.) Slender minnow.

Ohio River (Rafinesque, 1820a, as *Minulus dinemus*). Rockcastle River, Ky. (Jordan, 1876, as *Notropis dinemus*). Tributaries of Clinch River and very abundant in the Rockcastle and other upper tributaries of the Cumberland (Jordan and Brayton, 1878). Watauga and Doe Rivers near Elizabethton, Tenn., Middle Fork of the Holston near Glade Spring, and North Fork of the Holston near Saltville, Va., French Broad River and Warm Spring Creek at Hot Spring and Swannanoa River near Asheville, N. C. (Jordan, 1889). Rolling Fork of Salt River at Booth, and near New Market (Gilbert and Swain, 1884, collectors). Rough Creek at Hartford, Big Barren River and Drake Creek near Bowling Green, Little Barren River at Osceola, Green River and Pitman Creek near Greensburg, Tradewater River near Dawson Springs, Cumberland River near Kuttawa, Rockcastle River near Livingston (Gilbert, 1884, collector). Tennessee River near Paducah, Obion River near Cypress, Bayou de Chien near Moscow, upper Kentucky River, Levisa Fork of the Big Sandy near Pikeville, John Creek near Zebulon, Blaine Creek near Catalpa, and mouth of the Big Sandy (Gilbert and Henshall, 1888, collectors). Licking River and Triplet Creek near Farmer, and Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Spring Creek near Springcreek railroad station, Round Lick Creek near Watertown, Smith Fork near Lancaster, Obeys River and Eagle Creek near Olympus, and Wolf River near Byrdstown, Tenn., Cumberland River at the mouth of Willis Creek in Cumberland County, Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, Rock Creek near Whitley station, and Brimstone Creek near New River station, Ky. (Kirsch, 1893).

67. **Notropis arge** (Cope). (500.)

Big Barren River at Bowling Green, Green River near Greensburg, Horse Creek and Redbird Creek (South Fork of the Kentucky) near Big Creek, and North Fork of the Kentucky near Hazard (Woolman, 1892).

68. **Notropis dilectus** (Girard). (501.) Emerald minnow.

Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River near Greensburg, Rockcastle River near Livingston, and below the railroad bridge (Gilbert, 1884, collector). Powell River near Cumberland Gap, Redbird Creek (South Fork of the Kentucky) near Big Creek, Bull and Cutshin Creeks near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, and Left Troublesome Creek at Hindman, Right Fork of Beaver Creek at Lackey, Robinson and Shelby Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John Creek near Zebulon, Blaine Creek near Catalpa, and mouth of the Big Sandy (Gilbert and Henshall, 1888, collectors). Triplet Creek near Farmer (Woolman, 1892).

69. **Notropis photogenis** (Cope). (504.)

Abundant in the French Broad (Jordan and Brayton, 1878).

70. **Notropis micropteryx** (Cope). (507.)

Holston River (Cope, 1869, as *Alburnellus micropteryx*, type). French Broad and Rockcastle Rivers (Jordan, 1876). Tributaries of Holston and Clinch Rivers and abundant in Rockcastle River (Jordan and Brayton, 1878). Tennessee and Cumberland Rivers (Jordan, 1878). Richland Creek near Pulaski, Tenn. (Gilbert and Swain, 1884, collectors). Clinch River at Walkers Ford, and Tennessee River near Knoxville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

71. **Notropis lirus** Jordan. (510.)

Elk River at Estill Springs, Tenn., and Chickamauga River near Ringgold, Ga. (Jordan and Brayton, 1878). Tennessee River (Jordan, 1878). Tennessee River near Florence (Gilbert and Swain, 1884, collectors).

72. **Notropis umbratilis lythrurus** (Jordan). (512b.)

Small streams which fall into the Elkhorn and Kentucky Rivers (Rafinesque, 1820a, as *Rutilus*(?) *ruber*, type). Rockcastle and Cumberland Rivers (Jordan, 1876, as *Lythrurus ardens*). Very abundant everywhere in the Cumberland (Jordan and Brayton, 1878, as *Lythrurus ardens*). Cumberland River (Jordan, 1878, as *Lythrurus ardens*). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Minnilus diplæmius*). Indian, Willis, Spring, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892, as *Notropis umbratilis cyanocephalus*). Spring Creek at Springcreek station, Round Lick Creek at Watertown, Roaring River near Windle, Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Cumberland River in Cumberland County, Willis Creek at its mouth, Otter Creek between Monticello and Albany, Canada Creek 8 miles above its mouth, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, and New River and Brimstone Creek near New River Station, Ky. (Kirsch, 1893). Rolling Fork of Salt River near New Market (Gilbert and Swain, 1884, collectors). Pond Creek near Rockport and Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River at Osceola, Green River near Greensburg, Tradewater River near Dawson Springs, Clear Creek near Wildie, Cumberland River near Barbourville, Cumberland River near Pineville, Richland Creek near Barbourville, Smoky Fork of Richland Creek near its mouth, Straight Creek near Pineville, and Rockcastle River below the railroad bridge (Gilbert, 1884, collector), and near Livingston (Jordan and Gilbert, 1876, collectors). Smith Creek, Spring Creek, Albany Branch, Indian Creek, and pond near Albany (Kirsch, 1889–90, collector). Mayfield Creek near Hickory Grove, Obion River near Cypress, Redbird Creek (South Fork of the Kentucky) near Big Creek, and Bull Creek near Hyden (Woolman, 1892). Clear Fork of the Cumberland, and Wolf and Briar Creeks near Pleasant View, in Whitley County, Ky. (Jordan, 1883, collector; Woolman, 1892).

73. **Notropis umbratilis fasciolaris** Gilbert. (512e.)

French Broad River (Jordan, 1876), as *Lythrurus ardens*). Richland Creek near Pulaski, Tenn. (Gilbert and Swain, 1884, collectors). Streams about Florence (Gilbert, 1891, type).

74. **Ericymba buccata** Cope. (513.) Cavern-jawed minnow.

Wolf and Briar Creeks near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883). Rolling Fork of Salt River near Booth, Cumberland River and Richland Creek near Barbourville, Smoky Fork of Richland Creek near its mouth, Straight Creek near Pineville, Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector). Horse and Goose Creeks near Garratsville, Hector and Redbird Creeks near Big Creek, Big Creek at Big Creek post office, Bull and Cutshin Creeks and Middle Fork of the Kentucky near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Blaine Creek near Catalpa, Licking River and Triplet Creek near Farmer, and Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892).

75. **Phenacobius mirabilis** (Girard). (515.)

Stone River at Nashville (Gilbert and Swain, 1884, collectors).

76. **Phenacobius uranops** Cope. (517.)

Holston River near Saltville, Va. (Cope, 1867, type, and Cope, 1869). French Broad River, Tenn., and Rockcastle River, Ky. (Jordan, 1876). Rockcastle River, Ky. (Jordan, 1877, and Jordan and Brayton, 1878). Tennessee River (Jordan, 1878). Elk, Chickamauga, French Broad, and Holston Rivers (Jordan and Brayton, 1878). Duck River at Columbia, Tenn. (Gilbert and Swain, 1884, collectors). Swannanoa River near Asheville and Spring Creek at Hot Springs, N. C., Watauga River near Elizabethton and Beaver Creek near Bristol, Tenn., Middle Fork of the Holston near Glade Spring and North Fork of the Holston near Saltville, Va. (Jordan, 1889). Big Barren River and Drake Creek near Bowling Green, Green River near Greensburg, and Rockcastle River just below the railroad bridge (Gilbert, 1884, collector) and near Livingston (Jordan and Gilbert, 1876, collectors). Rockcastle River near Livingston, Ky. (Woolman, 1892). Obeys River and Eagle Creek near Olympus and Wolf River near Byrdstown, Tenn., and Willis Creek at its mouth in Cumberland County, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, and Clinch River at Walkers Ford, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

77. **Rhinichthys cataractæ** (Cuvier and Valenciennes). (521.) Long-nosed dace.

South Fork of Holston River near Holstein Mills, Va. (Jordan, 1889).

78. **Rhinichthys atronasus** (Mitchill). (523.) Black-nosed dace.

Tennessee River near Florence, Ala. (Storer, 1845, as *Leuciscus croceus*, type). Spring Branch of Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Rhinichthys obtusus*, type, and *Leuciscus croceus*). Tennessee River (Girard, 1856, and Günther, 1868, as *Rhinichthys obtusus*). Holston River (Günther, 1868, as *Rhinichthys nasutus*). Tributaries of the Holston (Cope, 1869, as *Rhinichthys lunatus*). Abundant in all clear rocky brooks and in outlets of springs (Jordan and Brayton, 1878, as *Rhinichthys obtusus*). Branch of Clinch River (Garman, 1881, as *Rhinichthys badius*, type). Tennessee River (Garman, 1881). Tennessee River near Florence, Ala. (Gilbert and Swain, 1884, collectors). South Fork of the Swannanoa at Black Mountain station, and North Fork of the Swannanoa at Burnett's mill, N. C., South Fork of the Holston near Holstein Mills, and Middle Fork of the Holston near Marion and Glade Spring, Va. (Jordan, 1889, as *Rhinichthys obtusus*). Spring Creek, Albany Branch, and Indian Creek in Clinton County, Ky. (Kirsch, 1889–90, collector). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector; Woolman, 1892). Roaring Fork near Windle, Tenn., and Cumberland River near mouth of Willis Creek in Cumberland County, Ky. (Kirsch, 1893). Indian Creek and Solomon's Cave at Cumberland Gap, Ball Creek, and Nigger Cave near Tazewell, Roaring Fork near Greenville, Eastaunaula Creek and Norvel Spring branch near Athens, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

79. **Hybopsis hyostoma** (Gilbert). (536.)

Clinch River at Clinton and Stone River at Nashville, Tenn. (Gilbert and Swain, 1884, collectors). Big Barren River near Bowling Green, Little Barren River at Osceola, Green River near Greensburg, Blaine Creek near Catalpa, and Licking River and Triplet Creek near Farmer (Woolman, 1892). Clinch River at Walkers Ford and Tennessee River near Knoxville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

80. **Hybopsis monacus** (Cope). (541.)

Holston River in Washington County, Va. (Cope, 1869, as *Ceratichthys monacus*, type). Holston River, and abundant in Chickamauga River near Ringgold, Ga. (Jordan and Brayton, 1878, as *Ceratichthys monachus*). Tennessee River (Jordan, 1878, as *Ceratichthys monachus*). Shoal Creek near Florence, Ala. (Gilbert and Swain, 1884, collectors). Swannanoa River near Asheville and Spring Creek near Hot Springs, N. C., and North Fork of Holston River near Saltville, Va. (Jordan, 1889, as *Hybopsis monachus*).

81. **Hybopsis dissimilis** (Kirtland). (542.) Spotted shiner.

Elk River near Estill Springs, Tenn., and Cumberland River at Nashville (Jordan and Brayton, 1878, as *Ceratichthys dissimilis*). Tennessee River near Florence, Ala. (Gilbert and Swain, 1884, collectors). Swannanoa River near Asheville and Spring Creek near Hot Springs, N. C. (Jordan, 1889). Rolling Fork of Salt River near Booth (Woolman, 1892). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Tennessee River near Knoxville, and Tellico River at Tellico Plains, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

82. **Hybopsis watauga** Jordan and Evermann. (543.) Watauga shiner.

Watauga River near Elizabethton, Tenn., and North Fork of the Holston near Saltville, Va. (Jordan, 1888, type, and Jordan, 1889). Big Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, Green River near Greensburg, Powell River near Cumberland Gap, Redbird Creek near Big Creek post office (Woolman, 1892). Caney Fork River and Smith Fork of Caney River near Lancaster, and Obeys River near Olympus, Tenn. (Kirsch, 1893).

83. **Hybopsis amblops** (Rafinesque). (547.) Big-eyed shiner; silver chub.

Ohio River at the Falls (Rafinesque, 1820a, as *Rutilus Amblops*, type). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Hybopsis gracilis*, type). Tributaries of the Holston (Cope, 1869, as *Ceratichthys hyalinus*, type). Powell River, Tenn. (Jordan, 1876, as *Ceratichthys gracilis*). Everywhere abundant in the Tennessee (Jordan and Brayton, 1878, as *Ceratichthys winchelli*). Cumberland River at Nashville (Jordan and Brayton, 1878, as *Ceratichthys amblops*). Tennessee River near Florence, Ala., and Wolf Creek in Cocke County, Tenn. (Gilbert and Swain, 1884, collectors). Swannanoa River near Asheville, Spring Creek near Hot Springs, N. C., Watauga and Doe Rivers near Elizabethton, Beaver Creek near Bristol, Tenn., South Fork of the Holston at Holstein Mills, Middle Fork of the Holston near Marion and Glade Spring, and North Fork of the Holston near Saltville, Va. (Jordan, 1889). Rolling Fork of Salt River near Booth, Pond Creek near Rockport, Rough Creek near Hartford, Green River and Pitman Creek near Greensburg, Tradewater River near Dawson Springs, Cumberland River near Barbourville, and Indian Creek in Clinton County, Ky. (Kirsch, 1889–90, collector). Powell River near Cumberland Gap, Mayfield Creek near Hickory Grove, Goose Creek near Garratsville, Hector Creek near Big Creek post office, Redbird Creek near Big Creek, Middle Fork of the Kentucky and Cutshin Creek near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Fork of Beaver Creek at Lackey, Robinson Creek near Robinson, Island Creek near Pikeville, John Creek near Zebulon, and Triplet Creek near Farmer (Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Springcreek station, Smith Fork near Lancaster, Eagle Creek near Olympus, Wolf Creek near Byrdstown, Tenn., Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, and Rock Creek near Whitley station, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, Tennessee River near Knoxville, Roaring Fork near Greenville, Tellico River at Tellico Plains, Eastaunaula Creek near Athens, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hilderbrand, 1916).

84. **Hybopsis storerianus** (Kirtland). (548.) Storer's chub.

Falls of the Ohio (Jordan, 1879, as *Ceratichthys lucens*, type). Stone River near Nashville, and Rolling Fork (Gilbert and Swain, 1884, collectors). Rolling Fork of Salt River at New Haven and near Booth (Gilbert and Swain, 1884, collectors). Rough Creek near Hartford, Cumberland River near Kuttawa, Bayou de Chien, near Moscow, Tennessee River near Paducah, and Little Sandy River (Gilbert and Henshall, 1888, collectors; Woolman, 1892).

85. **Hybopsis kentuckiensis** (Rafinesque). (550.) River chub.

Ohio River (Rafinesque, 1820a, as *Luxilus Kentuckiensis*, type). Holston River (Cope, 1869, as *Ceratichthys biguttatus*). Powell River, Tenn. (Jordan, 1876, as *Ceratichthys biguttatus*). Everywhere abundant in the Cumberland and Tennessee Basins (Jordan and Brayton, 1878, as *Ceratichthys biguttatus*). North Fork of the Holston near Saltville, Middle Fork of the Holston near Marion and Glade Spring, South Fork of the Holston near Holstein Mills, Va., Beaver Creek near Bristol and Watauga and Doe Rivers near Elizabethton, Tenn., Spring Creek and French Broad River near Hot Springs, Swannanoa River near Asheville, and South Fork of the Swannanoa near Black Mountain station, N. C. (Jordan, 1889). Pond Creek near Rockport, Rough Creek near Hartford, Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, Green River near Greensburg, and Rockcastle River just below the railroad bridge (Gilbert, 1884, collector). Clear Creek near Wildie, Rockcastle River near Livingston, Cumberland River near Barbourville, and Smith, Spring, and Albany Creeks and pond near Albany, in Clinton County, Ky. (Kirsch, 1889–90, collector). Powell River near Cumberland Gap, Horse Creek near Garratsville, Hector and Redbird Creeks near Big Creek post office, Bull Creek, Middle Fork of the Kentucky, and Cutshin Creek near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Right Fork of Beaver Creek at Lackey, Robinson Creek at Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Licking River and Triplet Creek near Farmer, Clear Creek near Wildie, Rockcastle River near Livingston, and Cumberland River near Barbourville, Ky. (Woolman, 1892). Spring, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Springcreek station, Roaring River near Windle, Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Beaver Creek in Wayne County, Little South Fork of the Cumberland near mouth of Canada Creek, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, and New River and Brimstone Creek near New River station, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, Tennessee River near Knoxville, Tellico River at Tellico Plains, Eastaunaula Creek near Athens, Arnwine Spring Creek near Mount Verd, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley 1893, collectors; and Evermann and Hildebrand, 1916).

86. **Anguilla chrisypa** Rafinesque. (588.) Common eel.

Cumberland, Green, and Licking Rivers (Rafinesque, 1820, as *Anguilla lutea*, type). Tennessee and Cumberland Rivers (Rafinesque, 1820, as *Anguilla aterrima*, type, and Jordan and Brayton, 1878, as *Anguilla vulgaris*). Rockcastle River at mouth of Round Stone River, and common in the Cumberland (Jordan and Brayton, 1878, as *Anguilla vulgaris*). Wolf River and Ill-will Creek in Clinton County, Ky. (Kirsch, 1892). Tradewater River near Dawson Springs, and Rockcastle River just below the railroad bridge (Gilbert, 1884, collector). Bayou de Chien near Moscow (Woolman, 1892). Falls of the Ohio (Evermann, 1902).

87. **Hiodon alosoides** (Rafinesque). (689.) Toothed herring; moon-eye.

Lower parts of the Ohio and at the Falls (Rafinesque, 1820a, as *Hyodon amphiodon*, type). Rolling Fork of Salt River near Booth and Cumberland River near Kuttawa, Ky. (Woolman, 1892). Falls of the Ohio (Evermann, 1902).

88. **Hiodon tergisus** Le Sueur. (690.) Toothed herring; moon-eye.

Falls of the Ohio (Rafinesque, 1818, as *Glossodon heterurus*, type). Ohio River and tributary streams (Rafinesque, 1820a, as *Hyodon heterurus*). All over the Ohio and even at Pittsburgh (Rafinesque, 1820a, as *Hyodon vernalis*). As far as Pittsburgh in May (Rafinesque, 1820a, as *Hyodon clodalus* [misprint for *tergisus*, see p. 98]). Abundant in the Cumberland (Jordan and Brayton, 1878, as *Hyodon tergisus*).

89. **Hiodon selenops** Jordan and Bean. (691.) Southern toothed herring; moon-eye.

Cumberland River (Jordan, 1877a, Jordan, 1878, and Jordan and Brayton, 1878, as *Hyodon selenops*). Rolling Fork of Salt River near Booth, and Pitman Creek near Greensburg, Ky. (Woolman, 1892).

90. **Dorosoma cepedianum** (Le Sueur). (693.) Hickory shad.

Falls of the Ohio (Rafinesque, 1820a, as *Dorosoma notata*, type). Abundant in the lower Cumberland and Tennessee Rivers (Jordan and Brayton, 1878, as *Dorosoma cepedianum heterurum*). Rolling Fork of Salt River near Booth, Pond Creek near Rockport, Cumberland River near Kuttawa, Tennessee River near Paducah, Obion River near Cypress, Bayou de Chien near Moscow, near mouth of the

Big Sandy, and Little Sandy River, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Falls of the Ohio (Evermann, 1902).

91. **Pomolobus chrysochloris** Rafinesque. (705.) Skipjack

Falls of the Ohio (Rafinesque, 1820a, type). Abundant in the lower Cumberland and in the channel of the lower Tennessee (Jordan and Brayton, 1878). Clinch River at Clinton and Stone River at Nashville, Tenn. (Gilbert and Swain, 1884, collectors). Willis Creek, Clinton County, Ky. (Kirsch, 1892, as *Clupea chrysochloris*). Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; and Woolman, 1892, as *Clupea chrysochloris*). Obeys River at Olympus, Tenn., and Willis Creek near its mouth in Cumberland County, Ky. (Kirsch, 1893, as *Clupea chrysochloris*).

92. **Alosa ohiensus** Evermann. (709+.) Ohio shad.

Ohio River at the Falls (Evermann collector, May, 1898; Evermann, 1902, type).

93. **Salvelinus fontinalis** (Mitchill). (801.) Eastern brook trout.

Headwaters of Holston River (Cope, 1869, as *Salmo fontinalis*). Abundant in the Swannanoa at the foot of Black Mountain and in all clear tributaries of the French Broad in western North Carolina, in certain tributaries of the Holston in southwestern Virginia, and in Rabun County, Ga., it abounds in the headwaters of the Little Tennessee (Jordan and Brayton, 1878). North Fork of Swannanoa River at Burnett's mill near foot of Black Mountain, N. C. (Jordan 1889).

94. **Lucius vermiculatus** (Le Sueur). (941.) Little pickerel.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Esox crassus*, type, and Gilbert and Swain, 1884, collectors). Mayfield Creek near Hickory Grove, Obion River near Cypress, Bayou de Chien near Moscow, and Triplet Creek near Farmer, Ky. (Woolman, 1892).

95. **Lucius lucius** (Linnæus). (943.) Common pike.

Ohio River (Rafinesque, 1818a, as *Esox vittatus*). Crab Orchard, Ky. (Le Sueur in Cuvier and Valenciennes, 1838, as *Esox lugubrosus*, collector Le Sueur).

96. **Fundulus catenatus** (Storer). (963.)

Tennessee River near Florence, Ala. (Storer, 1845, as *Pœcilia catenata*, type). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Hydrargyra catenata*). Abundant in some tributaries of the Holston (Cope, 1869). Powell and Clinch Rivers, Tenn. (Jordan, 1876). Cumberland River (Jordan, 1878, as *Xenisma catenatum*). Florence, Ala., and abundant in the Elk, Clinch, and Holston Rivers in clear water, and in streams about Nashville, Tenn. (Jordan and Brayton, 1878, as *Xenisma catenatum*). Tennessee River near Florence, Ala. (Gilbert and Swain, 1884, collectors). North Fork of the Holston near Saltville, Va. (Jordan, 1889). Indian and Willis Creeks in Clinton County, Ky. (Kirsch, 1892). Green River near Greensburg, Cumberland River near Kuttawa, Straight Creek near Pineville, and Powell River near Cumberland Gap, Ky. (Woolman, 1892). Spring Creek at Springcreek station, Round Lick Creek near Watertown, Obeys River and Eagle Creek near Olympus, and Wolf River near Byrdstown, Tenn., Willis Creek at its mouth in Cumberland County, Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, and Canada Creek near its mouth, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, and Tellico River at Tellico Plains, Tenn. (Evermann, Scovell, and Gurley 1893, collectors; and Evermann and Hildebrand, 1916).

97. **Fundulus notatus** (Rafinesque). (986.) Top minnow.

Tributaries of the Ohio in Kentucky, Cumberland River at Williamsburg, and Little River, a tributary of it (Rafinesque, 1820, as *Semotilus* (?) *notatus*, type). Tennessee River near Florence, Ala. (Storer, 1845, as *Pœcilia olivacea*, type). Russellville, Ky. [probably from a tributary of Green River] (Baird and Girard, 1853, as *Fundulus tenellus*, type). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Zygonectes olivaceus*). Cumberland and Stone Rivers, and Florence, Ala. (Jordan and Brayton, 1878, as *Zygonectes notatus*). Tennessee River near Florence (Gilbert and Swain, 1884, collectors). Rolling Fork of Salt River near Booth, Drake Creek near Bowling Green, Cumberland River near Kuttawa, Mayfield Creek near Hickory Grove, Obion River near Cypress, Tradewater River near Dawson Springs, Bayou de Chien near Moscow, Ky. (Woolman, 1892, as *Zygonectes notatus*). West Fork of Stone River near Murfreesboro and Spring Creek at Springcreek station, Tenn. (Kirsch, 1893, as *Zygonectes notatus*). Norvell Spring near Athens, Tenn. (Evermann, Scovell, and Gurley 1893, collectors; and Evermann and Hildebrand, 1916).

98. **Gambusia affinis** (Baird and Girard). (1021.) Top minnow; Gambusia.

Huntingdon, Carroll County, Tenn. (Bean, 1885, U. S. N. M.). Cumberland River near Kuttawa, and Obion River near Cypress, Ky. (Woolman, 1892).

99. **Typhlichthys subterraneus** Girard. (1065.) Blindfish.

Well at Bowling Green, Ky., tributary to Green River (Girard, 1859, type; J. E. Younglove; collector). Lebanon, Wilson County, Tenn. (Putnam, 1872; J. M. Safford, collector). Moulton, Lawrence County, Ala. (Putnam, 1872; Thomas Peters, collector). Tennessee and Alabama (Jordan, 1882). Winehouse Cave near Shellmound, Tenn. (Evermann and Hildebrand, 1916).

100. **Chologaster agassizii** Putnam. (1066.)

Well in Lebanon, Wilson County, Tenn. [probably tributary to Cumberland River] (Putnam, 1872, type). Subterranean streams in Kentucky and Tennessee (Jordan, 1878).

101. **Amblyopsis spelæus** De Kay. (1069.) Mammoth Cave blindfish.

Mammoth Cave and subterranean streams of Kentucky (De Kay, 1842, type, and Jordan, 1878). Mammoth Cave, Ky., about 2½ miles from the entrance (Craige, 1842, "as a small eyeless fish").

102. **Aphredoderus sayanus** (Gilliams). (1171.) Pirate perch.

Creek near Florence, Ala. (Gilbert and Swain, 1884, collectors). Pond Creek near Rockport, Mayfield Creek near Hickory Grove, Obion River near Cypress, and Bayou de Chien near Moscow, Ky. (Woolman, 1892).

103. **Labidesthes sicculus** Cope. (1202.) Brook silverside; skipjack.

Cumberland River, Ky. (Jordan, 1876 and 1882). Coal Creek, a tributary of the Clinch River (Cope, 1877, and Jordan and Brayton, 1878). Abundant in Stone River near Murfreesboro, Tenn. (Jordan and Brayton, 1878). Tuscumbia and Florence, Ala. (Gilbert and Swain, 1884, collectors). Rough Creek near Hartford and Pond Creek near Rockport, Big Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, Green River near Greensburg, Tradewater River near Dawson Springs, Cumberland River near Kuttawa, Tennessee River near Paducah, Powell River near Cumberland Gap, Mayfield Creek near Hickory Grove, Obion River near Cypress, Bayou de Chien near Moscow, Horse and Goose Creeks near Garratsville, Redbird and Big Creeks near Big Creek station, Robinson Creek near Robinson, Levisa Fork of the Big Sandy near Pikeville, Triplet Creek near Farmer, and Little Sandy River, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek station, and Obeys River near Olympus, Tenn. (Kirsch, 1893).

104. **Pomoxis annularis** Rafinesque. (1409.) Crappie; newlight; campbellite.

Falls of the Ohio (Rafinesque, 1818b, type, and 1818c, and 1820a). Tennessee River near Huntsville, Ala. (Agassiz, 1854). Houston River, Ky. (Girard, 1857, as *Pomoxis nitidus*, type). Rockcastle River, Ky. (Jordan, 1876). Cumberland River at Nashville, Tenn. (Jordan and Brayton, 1878). Big Barren River near Bowling Green, Green River near Greensburg, Tradewater River near Dawson, Obion River near Cypress, Bayou de Chien near Moscow, and Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors). Mayfield Creek near Hickory Grove, Ky. (Woolman, 1892).

105. **Pomoxis sparoides** (Lacépède). (1410.) Calico bass; strawberry bass.

Cumberland River at Nashville (Jordan and Brayton, as *Pomoxys nigromaculatus;* collector, Prof. A. Winchell). Obion River near Cypress, and Bayou de Chien near Moscow, Ky. (Woolman, 1892).

106. **Centrarchus macropterus** (Lacépède). (1411.) Round sunfish; flier.

Mayfield Creek near Hickory Grove, Ky. (Woolman, 1892); doubtful record.

107. **Ambloplites rupestris** (Rafinesque). (1413.) Rock bass; goggle-eye; red-eye.

Tennessee, Green, and Cumberland Rivers, and Little River (a tributary of the Cumberland) (Rafinesque, 1820, as *Aplocentrus calliops*, type). Kentucky River and tributary streams (Rafinesque, 1820, as *Lepomis ictheloides*). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Ambloplites ictheloides*). Common in the Holston (Cope, 1869). Cumberland, Rockcastle, Powell, and French Broad Rivers (Jordan, 1876). Cumberland River (Cope, 1877). Cumberland and Tennessee Basins, everywhere abundant (Jordan and Brayton, 1878). Clear Fork, Wolf Creek, and Briar Creek near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883). Swannanoa River near Asheville, Spring Creek near Hot Springs, N. C., Watauga River near Elizabethton, Beaver Creek near Bristol, Tenn., South Fork of Holston at Holstein Mills, and Middle Fork of Holston near Marion and

Glade Spring, Va. (Jordan, 1889). Indian, Smith, Spring, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892). Little Barren River near Osceola, Green River and Pitman Creek near Greensburg, Cumberland River near Barbourville and Pineville, Smith, Spring, Albany Branch, and Indian Creeks in Clinton County, Ky., Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky., Powell River near Cumberland Gap, Tenn., Goose Creek near Garratsville, Redbird Creek (South Fork of the Kentucky) and Big Creek near Big Creek post office, Lot Creek near Hazard, and Middle Fork of the Kentucky near Hyden, Blaine Creek near Catalpa, and Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Smith Fork near Lancaster, Roaring Fork near Windle, Spring Creek at Springcreek station, Obeys River near Olympus, and Wolf River near Byrdstown, Tenn., Little South Fork of the Cumberland near mouth of Canada Creek and Brimstone Creek near New River station, Ky. (Kirsch, 1893). Clinch River at Walkers Ford, Roaring Fork near Greenville, Tellico River at Tellico Plains, and Eastaunaula Creek near Athens, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

108. **Chænobryttus gulosus** (Cuvier and Valenciennes). (1415.) Warmouth.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Calliurus punctulatus*, type). Lower Tennessee River (Jordan and Brayton, 1878). Cypress Creek near Florence, Ala. (Gilbert and Swain, 1884, collectors). Pond Creek near Rockport, Mayfield Creek near Hickory Grove, Obion River near Cypress, and Bayou de Chien near Moscow, Ky. (Woolman, 1892).

109. **Apomotis cyanellus** (Rafinesque). (1419.) Blue-spotted sunfish; green sunfish.

Ohio River (Rafinesque, 1819, as *Lepomis cyanellus*, type). Tributary streams of the Ohio, Kentucky, and Licking Rivers (Rafinesque, 1820a, as *Icthelis melanops*). Falls of the Ohio (Rafinesque, 1820a, as *Icthelis cyanella*). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Pomotis sanguinolentus*, *P. inscriptus*, and *P. bombifrons*, types). Holston River, Va. (Cope, 1869, as *Lepomis inscriptus*). Tennessee River (Jordan, 1877a, as *Xenotis sanguinolentus*, *Lepomus bombifrons*, and *Xenotis inscriptus*). Abundant in the Cumberland at Nashville (Jordan and Brayton, 1878). Huntsville, Ala. (Jordan and Brayton, 1878, as *Lepiopomus bombifrons*). Tennessee River (Jordan, 1878, as *Lepiopomus bombifrons*). Clear Fork and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883). Cumberland River (Bean, 1883, U. S. N. M.). Tennessee River near Florence, Tuscumbia, and Richland Creek at Pulaski, Tenn. (Gilbert and Swain, 1884, collectors). Huntingdon, Carroll County, Tenn. (Bean, 1885, U. S. N. M.). North Fork of the Holston near Saltville, Va. (Jordan, 1889). Indian, Willis, Spring, and Smith Creeks in Clinton County, Ky. (Kirsch, 1892, as *Lepomis cyanellus*). Pond Creek near Rockport, small artificial lake (of Cumberland River) near Kuttawa, Smoky Fork of Richland Creek near its mouth, Mayfield Creek near Hickory Grove, Blaine Creek near Catalpa, Triplet Creek near Farmer, Clear Fork of the Cumberland River and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector; Woolman, 1892, as *Lepomis cyanellus*). Beaver Creek in Wayne County, Ky. (Kirsch, 1893, as *Lepomis cyanellus*). Ball Creek near Tazewell, Clinch River at Walkers Ford, Tellico River at Tellico Plains, Arnwine Spring near Mount Verd, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

110. **Lepomis auritus** (Linnæus). (1424.) Redbreasted bream.

Rivers, creeks, and ponds of Kentucky (Rafinesque, 1820a, as *Icthelis aurita*).

111. **Lepomis garmani** Forbes. (1426.) Garman's sunfish.

Cumberland River near Barbourville, and Bayou de Chien near Moscow, Ky. (Woolman, 1892).

112. **Lepomis megalotis** (Rafinesque). (1427.) Long-eared sunfish.

Kentucky, Licking, and Sandy Rivers (Rafinesque, 1820a, as *Icthelis megalotis*, type). Abundant in the Cumberland (Jordan and Brayton, 1878, as *Xenotis megalotis*). Clear Fork and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883). Tennessee River near Florence (Gilbert and Swain, 1884, collectors). Middle Fork of the Holston at Glade Spring, Va. (Jordan, 1889). Indian Creek in Clinton County, Ky. (Kirsch, 1892). Rolling Fork of Salt River near New Haven and New Market, and near Booth (Gilbert and Swain, 1884, collectors). Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River and Pitman Creek near Greensburg, Tradewater River near Dawson, Cumberland River and a small artificial lake near Kuttawa, Rockcastle River below the railroad bridge and near Livingston (Gilbert and Swain, 1884, collectors), Clear Fork near Wildie, Rockcastle River near Livingston, Smoky Fork of Richland Creek near its mouth, Cumberland River near Barbourville and near Pineville, and Indian Creek in Clinton County, Ky. (Kirsch, 1889–90, collector). Powell River near Cumberland Gap, Mayfield Creek near Hickory Grove, Obion River near Cypress, Bayou de Chien near Moscow, Horse and Goose Creeks near Garratsville, Hector, Redbird (South Fork of the Kentucky), and Big Creeks near Big Creek post office, Bull and Cutshin Creeks and Middle Fork of the Kentucky near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Blaine Creek near Catalpa, Triplet Creek near Farmer, and Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors). Generally distributed in the upper Green River Basin, Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector; Woolman, 1892). West Fork of Stone River near Murfreesboro, Spring Creek at Springcreek station Round Lick Creek near Watertown, Smith Fork near Lancaster, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Beaver Creek in Wayne County, Ky.; Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley Station, and Brimstone Creek near New River station, Ky. (Kirsch, 1893).

113. **Lepomis macrochirus** Rafinesque. (1430.) Big-finned sunfish.

Ohio, Licking, and Green Rivers (Rafinesque, 1819, as *Lepomis macrochira*, type, and 1820a, as *Icthelis macrochira*). Clear Fork and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883). Clear Fork of the Cumberland River and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector). Tradewater River near Dawson, and Obion River near Cypress, Ky. (Woolman, 1892).

114. **Lepomis pallidus** (Mitchill). (1431.) Bluegill.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Pomotis incisor*, and *Pomotis obscurus*, type). Tennessee Basin (Jordan, 1876 and 1878, and Jordan and Brayton, 1878, as *Lepiopomus pallidus* and *L. obscurus*). Abundant in the Cumberland (Jordan and Brayton, 1878, as *Lepiopomus pallidus*). Cumberland River at Nashville (Jordan, 1876 and 1878, and Jordan and Brayton, 1878, as *Lepiopomus obscurus;* collector, Prof. A. Winchell). Tennessee River near Florence, Ala. (Gilbert and Swain, 1884, collectors). Middle Fork of the Holston near Glade Spring, Va. (Jordan, 1889). Pond Creek near Rockport, Green River near Greensburg, Tradewater River near Dawson, Cumberland River and small artificial lake near Kuttawa, Rockcastle River below the railroad bridge (Gilbert and Swain, 1884, collectors). Bayou de Chien near Moscow, Island Creek near Pikeville, Triplet Creek near Farmer, and Little Sandy River near its mouth, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). West Fork of Stone River near Murfreesboro, and Spring Creek at Springcreek station, Tenn. (Kirsch, 1893). Arnwine Spring Creek near Mount Verd, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

115. **Eupomotis pallidus** (Agassiz). (1432.) Sunfish.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Pomotis pallidus*, type). Huntsville, Ala. (Jordan and Brayton, 1878).

116. **Eupomotis heros** (Baird and Girard). (1433.) Sunfish.

Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Pomotis notatus*, type). Tennessee River (Jordan, 1876, as *Lepomis notatus*). Tennessee River (Jordan, 1877a, as *Xystroplites notatus*). Huntsville, Ala., and upper waters of the Tennessee (Jordan and Brayton, 1878, as *Xystroplites notatus*). Bayou de Chien near Moscow, Ky. (Woolman, 1892).

117. **Micropterus dolomieu** Lacépède. (1437.) Smallmouth black bass.

Falls of the Ohio (Rafinesque, 1820a, as *Calliurus punctulatuse*, type). Kentucky, Green, Licking, and Ohio Rivers (Rafinesque, 1820a as *Lepomis salmonea*). Ohio and Salt Rivers, etc. (Rafinesque, 1820a, as *Etheostoma calliura*, type). Ohio River and many other streams (Rafinesque, 1820a, as *Lepomis trifasciata*, type). Ohio and tributaries (Rafinesque 1820a, as *Lepomis flexuolaris*, type). Ohio, Kentucky, Green, and Licking Rivers, etc. (Rafinesque, 1820a, as *Lepomis salmonea* and *Lepomis notata*). Abundant in Holston River (Cope, 1869, as *Micropterus fasciatus*). Cumberland River (Cope, 1877, as

Micropterus fasciatus). Clear Fork and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883, as *Micropterus dolomiei*). Middle Fork of the Holston near Glade Spring, North Fork of the Holston near Saltville, Va., Beaver Creek near Bristol, Watauga River near Elizabethton, French Broad River and Spring Creek near Hot Springs, N. C., and Swannanoa River near Asheville, N. C. (Jordan, 1889). Rolling Fork of Salt River near New Haven (Gilbert and Swain, 1884, collectors), Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River and Pitman Creek near Greensburg, Tradewater River near Dawson, Cumberland River and artifical lake near Kuttawa, Clear Creek near Wildie, Little Rockcastle River and Rockcastle River near Livingston, Cumberland River and Richland Creek near Barbourville, Smoky Fork of Richland Creek near its mouth, Cumberland River near Pineville, and Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County (Jordan, 1883, collector). Tennessee River near Paducah, Powell River near Cumberland Gap, Obion River near Cypress, Bayou de Chien near Moscow, Horse and Goose Creeks near Garratsville, Hector, Redbird (South Fork of the Kentucky), and Big Creek near Big Creek post office, Bull and Cutshin Creeks and Middle Fork of the Kentucky near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Island Creek and Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Blaine Creek near Catalpa, Triplet Creek near Farmer, and Little Sandy River near its mouth, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). West Fork of Stone River near Murfreesboro, Smith Fork near Lancaster, Roaring River near Windle, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Cumberland River near mouth of Willis Creek in Cumberland County, Ky., Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, Canada Creek near its mouth, Brimstone Creek near New River station, Ky., and Spring Creek at Springcreek station, Tenn. (Kirsch, 1893). Indian Creek near Cumberland Gap, Bull Creek near Tazewell, Clinch River at Walkers Ford, and Tellico River at Tellico Plains, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

118. **Micropterus salmoides** (Lacépède). (1438.) Largemouth black bass; straw bass.

Ohio River (Rafinesque, 1820a, as *Lepomis pallida*, type). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Grystes nobilis*, type). Rockcastle River, Ky. (Jordan, 1876, as *Micropterus pallidus*). Tennessee River and Cumberland River below the falls and introduced above the falls (Jordan and Brayton, 1878, as *Micropterus pallidus* and *Micropterus salmoides*). Rough Creek near Hartford, Green River Basin, Tradewater River near Dawson, Cumberland River near Kuttawa, Cumberland River near Barbourville, Obion River near Cypress, Bayou de Chien near Moscow, Goose Creek near Garratsville, Redbird (South Fork of the Kentucky) and Big Creek near Big Creek post office, Middle Fork of the Kentucky near Hyden, Beaver Creek near Lackey, Island Creek near Pikeville, John and Coon Creeks near Zebulon, Blaine Creek near Catalpa, Triplet Creek near Farmer, and Little Sandy River near its mouth, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Cumberland River and Willis Creek near its mouth in Cumberland County, Ky. (Kirsch, 1893). Clinch River at Walkers Ford, Tenn., and Chickamauga Creek at Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

119. **Stizostedion vitreum** (Mitchill). (1441.) Wall-eyed pike; "salmon;" "white salmon."

Ohio River (Rafinesque 1818, as *Perca salmonea*, type). Ohio, Kentucky, and Licking Rivers (Rafinesque, 1820a, as *Perca salmonea*). Tennessee River (Jordan, 1876, as *Stizostedion salmoneum*). Rockcastle River at Livingston, Ky. (Jordan, 1876, and Jordan and Brayton, 1878, as *Stizostethium salmoneum*). French Broad River (Cope, 1877a, as *Stizostedium americanum*). French Broad River and throughout the Tennessee Basin (Jordan and Brayton, 1878, as *Stitzosethium vitreum* and *S. salmoneum*). Tennessee River near Paducah, Levisa Fork of the Big Sandy near Pikeville, and Cumberland River near Kuttawa, Green River and Pitman Creek near Greensburg, and Little Sandy River near its mouth, Ky. (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Smith Fork near Lancaster, Tenn. (Kirsch, 1893). Tellico River at Tellico Plains, and French Broad River near Newport, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

120. **Stizostedion canadense** (Smith). (1442.) Sauger.

Indian Creek in Clinton County, Ky. (Kirsch, 1892). Clinton County, Ky. (Kirsch, 1889–90, collector; and Woolman, 1892). Big Sandy River and Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; and Woolman, 1892). Big Sycamore Creek near Tazewell, Tenn. (Gurley, 1893, collector; Evermann and Hildebrand, 1916).

121. **Percina caprodes** (Rafinesque). (1445.) Log perch.

Ohio River (Rafinesque, 1818, as *Sciæna caprodes*, type). Ohio, Cumberland, Tennessee, Kentucky, Green, and Licking Rivers (Rafinesque, 1820, as *Etheostoma caprodes*). Holston River (Cope, 1869). South Fork of Cumberland River in Campbell County, Tenn. (Cope, 1870). Cumberland and Rockcastle Rivers (Jordan, 1876). Abundant in the Cumberland Basin (Jordan and Brayton, 1878). Tennessee River near Florence, Ala., Clinch River at Clinton, Stone River near Nashville, Tenn., and Rockcastle River near Livingston, Ky. (Gilbert and Swain, 1884, collectors). Swannanoa River near Asheville, N. C., Watauga River near Elizabethton, Tenn., and North Fork of the Holston near Saltville, Va. (Jordan, 1889, as *Etheostoma caprodes*). Willis Creek in Clinton County, Ky. (Kirsch, 1892, as *Etheostoma caprodes*). Rolling Fork of Salt River near New Haven and near Booth (Gilbert and Swain, 1884, collectors), Rough Creek near Hartford, Big Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, Green River near Greensburg, Cumberland River near Kuttawa, and Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors). Rockcastle River near Livingston (Jordan and Gilbert, 1876, collectors). Rockcastle River near Livingston, Clear Creek near Wildie, Cumberland River and Straight Creek near Pineville, Powell River near Cumberland Gap, Tennessee River near Paducah, Obion River near Cypress, and Bayou de Chien near Moscow, Ky. (Woolman, 1892, as *Etheostoma caprodes*). West Fork of Stone River near Murfreesboro, Spring Creek at Springcreek station, Smith Fork near Lancaster, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Willis Creek at its mouth in Cumberland County, Ky., Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Big South Fork of the Cumberland near the mouth of Rock Creek, and New River and Brimstone Creek snear New River tation, Ky. (Kirsch, 1893, as *Etheostoma caprodes*). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, and Tennessee River near Knoxville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; Evermann and Hildebrand, 1916).

122. **Hadropterus phoxocephalus** (Nelson). (1446.) Nelson's darter.

Tennessee River (Jordan, 1878f, as *Etheostoma phoxocephalum*). Cumberland River at Nashville (Jordan and Brayton, 1878, as *Alvordius phoxocephalus*). Stone River near Nashville and Harpeth River near Franklin, Tenn., and Rockcastle River near Livingston, Ky. Rolling Fork of Salt River near New Haven and near Booth, Pond Creek near Rockport, Rough Creek near Hartford, Drake Creek near Bowling Green, Green River and Pitman Creek near Greensburg, Tradewater River near Dawson, Cumberland River near Kuttawa, and Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors; and Woolman, 1892). Mayfield Creek near Hickory Grove, and Levisa Fork of the Big Sandy near Pikeville, Ky. (Woolman, 1892, as *Etheostoma phoxocephalum*).

123. **Hadropterus macrocephalus** (Cope). (1447.)

North Fork of the Holston near Saltville, and Middle Fork of the Holston near Glade Spring, Va. (Jordan, 1889, as *Etheostoma macrocephalum*). Big Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, Beaver Creek near Glasgow, Green River near Greensburg, and Levisa Fork of the Big Sandy near Pikeville, Ky. (Woolman, 1892, as *Etheostoma macrocephalum*). Obeys River and Eagle Creek near Olympus, Tenn., and Little South Fork of the Cumberland near mouth of Canada Creek, Ky. (Kirsch, 1893, as *Etheostoma macrocephalum*). Indian Creek near Cumberland Gap (Gurley, 1893, collector; Evermann and Hildebrand, 1916).

124. **Hadropterus maculatus** (Girard). (1448.)

Rockcastle and Cumberland Rivers at various places (Jordan, 1876, and Jordan and Brayton, 1878, as *Alvordius maculatus*). French Broad River (Jordan, 1876, as *Alvordius maculatus*). Chickamauga River near Ringgold, Ga., and Clinch and French Broad Rivers (Jordan and Brayton, 1878, as *Alvordius maculatus*).

125. **Hadropterus aspro** (Cope and Jordan). (1449.) Black-sided darter.

Rockcastle River near Livingston, Ky. (Gilbert and Swain, 1884 collectors). Clear Fork of the Cumberland near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883, as *Alvordius aspro*). Smith Fork near Lancaster, Tenn., Cumberland River near mouth of Willis Creek in Cumberland County, Ky., Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley Station, Ky., and Brimstone Creek near New River station, Ky. (Kirsch, 1893, as *Etheostoma aspro*). Rough Creek near Hartford, Big Barren River near Bowling Green and Green River near Greensburg, Tradewater River near Dawson, Cumberland River near Kuttawa, Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors) and near Livingston (Jordan and Gilbert, 1876, collectors). Clear Creek near Wildie, Rockcastle River near Livingston, Cumberland River near Barbourville, and Straight Creek near Pineville, Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector). Powell River near Cumberland Gap, Mayfield Creek near Hickory Grove, Obion River near Cypress, Bayou de Chien near Moscow, Goose Creek near Garratsville, Big Creek near Big Creek post office, Middle Fork of the Kentucky near Hyden, Troublesome Creek near Dwarf, and Levisa Fork of the Big Sandy near Pikeville, Ky. (Woolman, 1892, as *Etheostoma aspro*). Ball Creek near Tazewell, Tenn. (Gurley, 1893, collector; Evermann and Hildebrand, 1916).

126. **Hadropterus ouachitæ** (Jordan and Gilbert). (1452.) Ouachita darter.

Rough Creek near Hartford, and Obion River near Cypress, Ky. (identification doubtful) (Woolman, 1892, as *Etheostoma ouachitæ*).

127. **Hadropterus evides** (Jordan and Copeland). (1454.)

Duck River at Columbia, Tenn. (Gilbert and Swain, 1884, collectors). Swannanoa River near Asheville, and Spring Creek and French Broad River near Hot Springs, N. C. (Jordan, 1889, as *Etheostoma evides*). Big Barren River near Bowling Green and Green River and Pitman Creek near Greensburg, Ky. (Woolman, 1892, as *Etheostoma evides*). Caney Fork River and Smith Fork near Lancaster, and Obeys River near Olympus, Tenn. (Kirsch, 1893, as *Etheostoma evides*). Clinch River at Walkers Ford and Tellico River at Tellico Plains, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; Evermann and Hildebrand, 1916).

128. **Hadropterus scierus** Swain. (1455.) Swain's darter.

Bull Creek near Hershells, Tenn. (Gilbert and Swain, 1884, collectors). Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; Woolman, 1892). Big Barren River near Bowling Green, Ky. (Woolman, 1892, as *Etheostoma scierum*). Clinch River at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; Evermann and Hildebrand, 1916).

129. **Hypohomus squamatus** Gilbert and Swain. (1457.)

Tennessee Basin (Jordan, 1885c). French Broad River at mouth of Wolf Creek, Tenn. (Gilbert, 1887, as *Etheostoma* (*Hadropterus*) *squamatus*, type). Spring Creek near Hot Springs, N. C., and Watauga River near Elizabethton, Tenn. (Jordan, 1889, as *Etheostoma squamatum*).

130. **Hypohomus aurantiacus** (Cope). (1458.)

North Fork of Holston River near Saltville, Va. (Cope, 1869, as *Cottogaster aurantiacus*, type). French Broad River in Madison County, N. C. (Cope, 1870, as *Cottogaster aurantiacus*, and Cope, 1877). French Broad River (Jordan and Brayton, 1878, as *Hadropterus aurantiacus*). French Broad River near Asheville, N. C. (Bean 1885, U. S. N. M.). Watauga River near Elizabethton, Tenn., and North Fork of Holston River near Saltville, Va. (Jordan, 1889). Clinch River at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors, and Evermann and Hildebrand, 1916).

131. **Hypohomus cymatotænia** (Gilbert and Meek). (1459.)

Big Barren River and Drake Creek near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, and Green River near Greensburg, Ky. (Woolman, 1892, as *Etheostoma cymatotænia*).

132. **Hypohomus spilotus** (Gilbert). (1461.)

Sturgeon Creek, a tributary of Kentucky River, near Travelers Rest, Owsley County, Ky. (Gilbert, 1887, as *Etheostoma nianguæ spilotum*, type). Hector Creek, Redbird Creek (South Fork of the Kentucky) and Big Creek, near Big Creek post office, Middle Fork of the Kentucky and Cutshin Creek near Hyden, Lot Creek near Hazard, Troublesome Creek near Dwarf, and Left Troublesome Creek near Hindman, Ky. (Woolman, 1892, as *Etheostoma spilotum*).

133. **Cottogaster copelandi** (Jordan). (1463.) Copeland's darter.

Rough Creek near Hartford, and Green River near Greensburg, Ky. (Woolman, 1892, as *Etheostoma copelandi*). Obeys River near Olympus, Tenn. (Kirsch, 1893, as *Etheostoma copelandi*). Tennessee River near Knoxville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; Evermann and Hildebrand, 1916).

134. **Cottogaster shumardi** (Girard). (1464.) Shumard's darter.

Rough Creek near Hartford, Cumberland River near Kuttawa, and Obion River near Cypress, Ky. (Woolman, 1892, as *Etheostoma shumardi*).

135. **Ulocentra meadiæ** Jordan and Evermann. (1464+.) Meadie's darter.

Indian Creek, a tributary of Powell River, near Cumberland Gap, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; Jordan and Evermann, 1896, type; and Evermannn and Hildebrand, 1916).

136. **Ulocentra stigmæa** (Jordan). (1465.)

Stone River near Nashville, Bull Run near Hershells, and Clinch River near Clinton, Tenn. (Gilbert and Swain, 1884, collectors). Clinch River near Clinton, Tenn. (Gilbert, 1887, as *Etheostoma (Etheostoma) saxatile*). Big Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, Green River near Greensburg, and Straight Creek near Pineville, Ky. (Woolman, 1892, as *Etheostoma stigmæum*). Smith Fork near Lancaster, Tenn., Willis Creek near its mouth in Cumberland County, Ky., Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, and Brimstone Creek near New River station, Ky. (Kirsch, 1893, as *Etheostoma stigmæum*). Ball Creek near Tazewell, and Arnwine Spring Creek near Mount Verd, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

137. **Ulocentra gilberti** Evermann and Thoburn. (1466.) Gilbert's darter.

Clinch River at Walkers Ford, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; Evermann and Thoburn, 1896, in Jordan and Evermann, type; and Evermann and Hildebrand, 1916).

138. **Ulocentra verecunda** (Jordan and Evermann). (1467.)

Middle Fork of the Holston 5 miles south of Glade Spring, Va. (Jordan, 1888, type; and Jordan, 1889).

139. **Ulocentra histrio** (Jordan and Gilbert). (1468.)

Rough Creek near Hartford, Ky. (Woolman, 1892, as *Etheostoma histrio*).

140. **Ulocentra simotera** (Cope). (1469.)

Holston River and its tributaries (Cope, 1869, as *Hyostoma simoterum*, type). Tributaries of Clinch River, Tenn. (Cope, 1870, as *Hyostoma simoterum*). Holston River (Vaillant 1873, as *Hiostoma simoterum*). French Broad River, Tenn. (Jordan, 1876). Rockcastle River, Ky. (Jordan, 1876 and 1877, as *Etheostoma simoterum*). Tributary of the Cumberland River near Nashville, Tenn. (Winchell, collector, and Jordan, 1877a, as *Arlina atripinnis*, type). Cumberland River (Jordan, 1877a, as *Diplesion simoterum*). Upper Tennessee River (Jordan, 1877a, as *Diplesion simoterum*). Clinch and Holston Rivers (Jordan and Brayton, 1878, as *Diplesium simoterum*). Tennessee River (Jordan, 1878, as *Diplesium simoterum*). Rockcastle River near Livingston, Ky. (Jordan and Brayton, 1878, as *Diplesium simoterum*). Cumberland River near Nashville (Jordan and Brayton, 1878, as *Ulocentra atripinnis*). Cumberland River (Jordan, 1878, as *Diplesium simoterum* and *Ulocentra atripinnis*). Stone River near Nashville and Rockcastle River near Livingston, Ky. (Gilbert and Swain, 1884, collectors). Middle Fork of the Holston near Marion, South Fork of the Holston near Holstein Mills, Va., and Beaver Creek near Bristol, Tenn. (Jordan, 1889, as *Etheostoma simoterum*). Cypress Creek near Florence, Ala., Richland Creek near Pulaski, Duck River near Columbia, Harpeth River near Franklin, Hines Creek near Clinton, Tenn., and Tennessee River near Huntsville, Ala. (Gilbert and Swain, 1884, collectors). Tributary of the Tennessee near Whiteside, Tenn. (Henshall, 1889, as *Etheostoma duryi*, type). Rare in the Green River Basin, Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors) and near Livingston (Jordan and Gilbert, 1876, collectors) and Redbird Creek (South Fork of the Kentucky) near Big Creek post office, Bull Creek and Middle Fork of the Kentucky near Hyden, and Troublesome Creek near Dwarf, Ky. (Woolman, 1892, as *Etheostoma simoterum*). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek station, Round Lick Creek near Watertown, Smith Fork near Lancaster, Eagle Creek near Olympus, and Canada Creek near its mouth (Kirsch, 1893, as *Etheostoma simoterum atripinnis*). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Roaring Fork near Greenville, Eastaunaula Creek near Athens, Arnwine Spring near Mount Verd, and

Tellico River at Tellico Plains, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

141. **Diplesion blennioides** Rafinesque. (1471.) Green-sided darter.

Ohio River (Rafinesque, 1820a, as *Etheostoma Blennioides*), Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Hyostoma newmanii*, type). Tributaries of the Holston near Saltville, Va. (Cope, 1869, as *Hyostoma blennioperca*, type). French Broad River, N. C. (Cope, 1870 and 1877, as *Hyostoma cymatogrammum*). Cumberland River in Campbell County, Tenn. (Cope, 1870). Headwaters of the Cumberland River in Tennessee (Cope, 1870, as *Hyostoma cymatogrammum*). Tennessee River (Jordan, 1876 and 1877a, as *Diplesion newmani*). Holston, French Broad, Tennessee near Huntsville, and Chickamauga Rivers (Jordan and Brayton, 1878). South Fork of Cumberland River, also Cumberland and Stone Rivers (Jordan and Brayton, 1878). Clear Fork of the Cumberland near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883). Duck River near Columbia, French Broad River near Big Creek, Stone River near Nashville, and Clinch River near Clinton, Tenn. (Gilbert and Swain, 1884, collectors). North Fork of the Holston near Saltville, and Middle Fork of the Holston near Glade Spring, Va., and Doe River near Elizabethton, Tenn. (Jordan, 1889, as *Etheostoma blennioides*). Indian, Spring, and Smith Creeks in Clinton County, Ky. (Kirsch, 1892, as *Etheostoma blennioides*). Rolling Fork of Salt River near New Haven and New Market, and near Booth (Gilbert and Swain, 1884, collectors). Big Barren River and Drake Creek near Bowling Green, Little Barren River near Osceola, and Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors), and near Livingston (Jordan and Gilbert, 1876, collectors). Smith, Spring, and Indian Creeks in Clinton County, Ky. (Kirsch, 1889–90, collector). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector). Horse and Goose Creeks near Garratsville, Redbird Creek (South Fork of the Kentucky) and Big Creek near Big Creek post office, Middle Fork of the Kentucky near Hyden, Troublesome Creek near Dwarf, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Island Creek near Pikeville, John Creek near Zebulon, and Cynthiania, Ky. (Henshall, collector, Woolman, 1892, as *Etheostoma blennioides*). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek station, Smith Fork near Lancaster, Roaring River near Windle, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Beaver Creek in Wayne County, Ky., Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, Rock Creek near Whitley station, and New River near New River station, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, and Tennessee River near Knoxville, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

142. **Boleosoma nigrum** (Rafinesque). (1474.) Johnny darter; "black minny"; "blind simon."

Green River, Ky. (Rafinesque, 1820a, as *Etheostoma nigra*, type). Holston River (Cope, 1869, as *Boleosoma olmstedi*, and Jordan and Brayton, 1878, as *Boleosoma maculatum*). Rockcastle River near Livingston, Ky. (Jordan, 1876, and Jordan and Brayton, 1878, as *Boleosoma maculatum*). Pond Creek near Rockport and Rough Creek near Hartford, Big Barren River, and Drake Creek near Bowling Green, and Green River near Greensburg, Tradewater River near Dawson, Tennessee River near Paducah, Mayfield Creek near Hickory Grove, Bayou de Chien near Moscow, Horse Creek near Garratsville, Hector, Redbird Creek (South Fork of the Kentucky), and Big Creek near Big Creek post office, Middle Fork of the Kentucky and Bull and Cutshin Creeks near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Shelby and Robinson Creeks near Robinson, Licking River and Triplet Creek near Farmer, Ky., and Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; Woolman, 1892, as *Etheostoma nigrum*).

143. **Boleosoma susanæ** Jordan and Swain. (1475.) Susan's darter.

Clear Fork of the Cumberland, and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan and Swain, 1883, type; and Woolman, 1892, as *Etheostoma susanæ*). Cumberland River (Jordan, 1885).

144. **Crystallaria asprella** (Jordan). (1477.) Crystal darter.

Green River near Greensburg, Ky. (Woolman, 1892, as *Etheostoma asprellum*).

145. **Ammocrypta pellucida** (Baird). (1478.) Sand darter.

Rolling Fork of Salt River near New Haven and near Booth (Gilbert and Swain, 1884, collectors). Rough Creek near Hartford, Green River near Greensburg, Little Barren River near Osceola, Cumberland River near Kuttawa, Straight Creek near Pineville, Powell River near Cumberland Gap, Redbird Creek (South Fork of the Kentucky) and elsewhere in sandy streams of the Kentucky River Basin, Levisa Fork of the Big Sandy River near Pikeville, Blaine Creek near Catalpa, and Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; Woolman, 1892, as *Etheostoma pellucidum*).

146. **Etheostoma variatum** Kirtland. (1482.)

South Fork of Cumberland River (Cope, collector; Jordan and Brayton, 1878, as *Pœcilichthys variatus*). Redbird Creek (South Fork of the Kentucky) and Cutshin Creeks near Big Creek post office, Middle Fork of the Kentucky near Hyden, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Falls of the Ohio, and Triplet Creek near Farmer, Ky. (Woolman, 1892). Indian Creek near Cumberland Gap (Gurley, 1893, collector; and Evermann and Hildebrand, 1916).

147. **Etheostoma swannanoa** Jordan and Evermann. (1483.) Swannanoa darter.

South Fork of the Swannanoa River near Black Mountain station, N. C. (type), Middle Fork of the Holston near Marion, and South Fork of the Holston near Holstein Mills, Va. (Jordan, 1888 and 1889).

148. **Etheostoma blennius** Gilbert and Swain. (1486.)

Cox and Shoal Creeks near Florence, Ala. (Gilbert and Swain in Gilbert, 1887, as *Etheostoma* (*Rhothœca*) *blennius*, type).

149. **Etheostoma rupestre** Gilbert and Swain. (1487.)

Tennessee River (Jordan, 1885).

150. **Etheostoma zonale** (Cope). (1489.)

Holston River, Va. (Cope, 1869, as *Pœcilichthys zonalis*, type). French Broad River in Madison County, N. C. (Cope, 1870 and 1877, as *Pœcilichthys zonalis*). Holston and French Broad Rivers (Jordan and Brayton, 1878, as *Nothonotus zonalis*). Cypress Creek near Florence, Ala., Wolf Creek in Cocke County, Tenn., and Rockcastle River near Livingston, Ky. (Gilbert and Swain, 1884, collectors). Cypress Creek near Florence, Ala., and Rolling Fork and Rockcastle Rivers, Ky. (Gilbert, 1887). North Fork of the Holston near Saltville, Middle Fork of the Holston near Glade Spring, Va., Beaver Creek near Bristol, Tenn., Spring Creek and French Broad River near Hot Springs, and Swannanoa River near Asheville, N. C. (Jordan, 1889). Rolling Fork of Salt River near New Haven and New Market and near Booth (Gilbert and Swain, 1884, collectors). Big Barren River near Bowling Green, Little Barren River near Osceola, Beaver Creek near Glasgow, Green River near Greensburg, and Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors) and Rockcastle River near Livingston (Jordan and Gilbert, 1876, collectors). Horse and Goose Creeks near Garratsville, Redbird Creek (South Fork of the Kentucky) and Big Creeks near Big Creek post office, Middle Fork of the Kentucky and Bull and Cutshin Creeks near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Licking River and Triplet Creek near Farmer, Ky., Little Sandy River near its mouth (Gilbert and Henshall, 1888, collectors; Woolman, 1892, as *Etheostoma zonale*). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Eastaunaula Creek near Athens, Tellico River at Tellico Plains, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

151. **Etheostoma camurum** (Cope). (1490.) Blue-breasted darter.

Headwaters of the Cumberland in Tennessee (Cope, 1870, as *Pœcilichthys camurus*, type). South Fork of the Cumberland (Cope, collector; Jordan and Brayton, 1878, and Jordan, 1882, as *Nothonotus camurus*). Rockcastle River near Livingston, Ky., and Duck River near Columbia, Tenn. (Gilbert and Swain, 1884, collectors). Spring Creek at Hot Springs, N. C. (Jordan, 1889). Green River near Greensburg, Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors), and near Livingston (Jordan and Gilbert, 1876, collectors). Ball Creek near Tazewell, Clinch River at Walkers Ford, Indian Creek near Cumberland Gap, Tennessee River near Knoxville, and Tellico River at Tellico Plains, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

152. **Etheostoma vulneratum** (Cope). (1491.)

Warm Spring Creek in Madison County, N. C. (Cope, 1870, as *Pœcilichthys vulneratus*, type; and Cope, 1877). French Broad River at Warm Springs, N. C. (Jordan and Brayton, 1878, and Jordan, 1878, as *Nothonotus vulneratus*).

153. **Etheostoma maculatum** Kirtland. (1492.)

Headwaters of the South Fork of the Cumberland (Cope, 1870, as *Pœcilichthys sanguifluus*, type). Cumberland River (Cope, collector; Jordan, 1877, as *Nothonotus sanguifluus*, and Jordan and Brayton, 1878). Holston, River, Va. (Jordan and Brayton, 1878, as *Boleosoma maculatum*). Clinch River near Clinton, Tenn., Rockcastle and Stone Rivers and Shoal Creek near Florence, Ala. Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors); and near Livingston (Jordan and Gilbert, 1876, collectors). Cynthiania, Ky. (Henshall, collector; Woolman, 1892). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, Tennessee River near Knoxville, and Tellico River at Tellico Plains, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

154. **Etheostoma cinereum** Storer. (1493.)

Tennessee River near Florence, Ala. (Storer, 1845, type). Florence, Ala. (Jordan, 1877a, as *Etheostoma cinerea*, and Jordan and Brayton, 1878, as *Etheostoma cinerea*). Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., and Little South Fork of the Cumberland near mouth of Canada Creek, and Canada Creek near its mouth (Kirsch, 1893).

155. **Etheostoma tessellatum** Storer. (1494.) Tessellated darter.

Tennessee River near Florence, Ala. (Storer, 1845, type). Florence, Ala. (Jordan, 1877a, as *Etheostoma tessellata*). Tennessee River near Florence (Jordan and Brayton, 1878, as *Etheostoma tessellata*).

156. **Etheostoma rufilineatum** (Cope). (1495.)

Warm Springs Creek in Madison County, N. C. (Cope, 1870, and 1877, as *Pœcilichthys rufilineatus*, type). French Broad River (Jordan, 1878, and Jordan and Brayton, 1878, as *Nothonotus rufilineatus*). Shoal Creek near Florence, Ala., and Clinch River near Clinton, Tenn. (Gilbert and Swain, 1884, collectors). North Fork of the Holston near Saltville, Middle Fork of the Holston near Marion and Glade Spring, South Fork of the Holston near Holstein Mills, Va., Spring Creek near Hot Springs, and Swannanoa River near Asheville, N. C. (Jordan, 1889). Big Barren River near Bowling Green, Clinton County, Ky. (Kirsch, 1889–90, collector, identification uncertain; Woolman, 1892, as *Etheostoma rufolineatum*). Indian Creek in Clinton County, Ky. (Kirsch, 1892). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek station, Caney Fork River near Lancaster, Eagle Creek near Olympus, Tenn., Little South Fork of the Cumberland near mouth of Canada Creek, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, and Rock Creek near Whitley station, Ky. (Kirsch, 1893). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Clinch River at Walkers Ford, and Tennessee River near Knoxville, Tenn. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916).

157. **Etheostoma sagitta** (Jordan and Swain). (1497.)

Wolf Creek near Pleasant View, Whitley County, Ky. (Jordan and Swain, 1883, as *Pœcilichthys sagitta*, type). Cumberland River (Jordan, 1885, and Woolman, 1892).

158. **Etheostoma jessiæ** (Jordan and Brayton). (1502.) Jessie's darter.

Chickamauga River near Ringgold, Ga. (Jordan and Brayton, 1878, as *Pœcilichthys jessiæ*, type, and Jordan, 1878).

159. **Etheostoma luteovinctum** Gilbert and Swain. (1503.)

Stone River near Nashville, Tenn. (Gilbert, 1887, type).

160. **Etheostoma cœruleum** Storer. (1505.) Rainbow darter.

South Fork of the Cumberland in Tennessee (Cope, 1870, as *Pœcilichthys cœruleus*). Cypress Creek near Florence, Ala. (Gilbert and Swain, 1884, collectors). Tributary of Tennessee River near Whiteside, Tenn. (Henshall, 1889, as *Etheostoma formosa*, type). Tyree Spring, Tenn. (Mr. Owen, collector, U. S. N. M.). Indian, Willis, Smith, Spring, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892). Rolling Fork of Salt River near New Haven and New Market and near Booth (Gilbert and Swain, 1884, collectors). Pond Creek near Rockport, Big Barren River near Bowling Green, Beaver Creek near Glasgow, Little Barren River near Osceola, Green River near Greensburg, and Rockcastle

River just below the railroad bridge (Gilbert and Swain, 1884, collectors). Near Livingston (Jordan and Gilbert, 1876, collectors). Hector, Redbird Creek (South Fork of the Kentucky), and Big Creek near Big Creek post office, Middle Fork of the Kentucky and Bull and Cutshin Creeks near Hyden, North Fork of the Kentucky and Lot Creek near Hazard, Troublesome Creek near Dwarf, Left Troublesome Creek near Hindman, Right Fork of Beaver Creek near Lackey, Shelby and Robinson Creeks near Robinson, Levisa Fork of the Big Sandy near Pikeville, John and Coon Creeks near Zebulon, Cynthiania (Henshall, collector); and Triplet Creek near Farmer, Ky. (Woolman, 1892). Roaring River near Windle, Obeys River and Eagle Creek near Olympus, Wolf River near Byrdstown, Tenn., Willis Creek near its mouth in Cumberland County, Ky., Albany Branch and Indian Creek in Clinton County, Ky. (Kirsch, 1889-90, collector). Otter Creek between Monticello and Albany, Little South Fork of the Cumberland near mouth of Canada Creek, Canada Creek near its mouth, Big South Fork of the Cumberland near mouth of Rock Creek west of Whitley station, and Brimstone Creek near New River station, Ky. (Woolman, 1892).

161. **Etheostoma obeyense Kirsch.** (1510.) Kirsch's darter.

Indian, Spring, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892, type; Woolman, 1892, as *Etheostoma* sp. nov.). Obeys River near Olympus, Tenn., Beaver Creek in Wayne County, Ky., Otter Creek between Monticello and Albany, Ky., Little South Fork of the Cumberland near mouth of Canada Creek, and Canada Creek near its mouth, Ky. (Kirsch, 1893).

162. **Etheostoma virgatum** (Jordan). (1512.)

Rockcastle River near Livingston, Ky. (Jordan, 1879, as *Pœcilichthys virgatus*). Cumberland River, Ky. (Jordan, 1882, as *Pœcilichthys virgatus*). Green River Basin, Rockcastle River just below the railroad bridge (Gilbert and Swain, 1884, collectors). Near Livingston (Jordan and Gilbert, 1876, collectors; Woolman, 1892).

163. **Etheostoma squamiceps** Jordan. (1517.)

Russellville, Ky., probably from a tributary of Green River (Jordan, 1877a, type; collector Dr. Bebb). Tuscumbia, Ala., Cypress Creek near Florence, Ala., Harpeth River near Franklin, Stone River near Nashville, and Duck River near Columbia, Tenn. (Gilbert and Swain, 1884, collectors). West Fork of Stone River near Murfreesboro, Spring Creek near Springcreek station, and Round Lick Creek near Watertown, Tenn. (Kirsch, 1893).

164. **Etheostoma flabellare** Rafinesque. (1518.) Fan-tailed darter.

Tributaries of the Ohio (Rafinesque, 1819, type). Springs and caves near Lexington, Ky. (Rafinesque, 1820, as *Etheostoma fontinalis*, type). Falls of the Ohio (Rafinesque, 1820a, as *Etheostoma flabellata*, type). Holston River (Cope, 1869, as *Pœcilichthys flabellatus*). Cumberland and Rockcastle Rivers, Ky. (Jordan, 1876). Abundant in mountain tributaries of the Cumberland and in the upper waters of the Tennessee in clear rapid streams (Jordan and Brayton, 1878). Bull Run near Hershells, Tenn., Cypress Creek near Florence, Ala., and Big Creek and Clinch River in Clinton County, Tenn. (Gilbert and Swain, 1884, collectors). Middle Fork of the Holston near Marion, South Fork of the Holston near Holstein Mills, Va., North Fork of the Swannanoa River near Burnett's mill, South Fork of the Swannanoa River near Black Mountain station, and Swannanoa River near Asheville, N. C, (Jordan, 1889). Green River near Greensburg, Smith and Indian Creeks and Albany Branch in Clinton County, Ky. (Kirsch, 1889-90, collector). Right Fork of Beaver Creek near Lackey, Island Creek and Levisa Fork of the Big Sandy near Pikeville, Coon Creek near Zebulon, Blaine Creek near Catalpa. Cynthiania (Henshall, collector); and Licking River and Triplet Creek near Farmer, Ky. (Woolman, 1892). Indian Creek near Cumberland Gap and Ball Creek near Tazewell, Tenn. (Gurley, 1893, collector; and Evermann and Hildebrand, 1916).

165. **Etheostoma flabellare cumberlandicum** (Jordan and Swain). (1518a.) Cumberland fan-tailed darter.

Clear Fork, and Wolf, Briar, Yellow, and Gap Creeks, and other small streams of the Cumberland Mountains in Whitley County, Ky. (Jordan and Swain, 1883, type). Cumberland River (Jordan, 1885). Indian, Smith, and Albany Creeks in Clinton County, Ky. (Kirsch, 1892, as *Etheostoma flabellare*). Clear Fork of the Cumberland and Wolf and Briar Creeks near Pleasant View in Whitley County, Ky. (Jordan, 1883, collector; Woolman, 1892, as *Etheostoma cumberlandicum*).

166. **Psychromaster tuscumbia** (Gilbert and Swain). (1520.) Tuscumbia darter.

Exceedingly abundant in the stream flowing from the large spring at Tuscumbia, Ala. (Gilbert and Swain, 1887, as *Etheostoma* (*Etheostoma*) *tuscumbia*, type). Tuscumbia Spring (Evermann, Jan. 8, 1901, collector).

167. **Boleichthys fusiforme** (Girard). (1522.)

Tradewater River near Dawson, Mayfield Creek near Hickory Grove, and Bayou de Chien near Moscow, Ky. (Woolman, 1892.)

168. **Microperca punctulata** Putnam. (1525.) Least darter.

Little Barren River near Osceola, Ky. (Woolman, 1892, as *Etheostoma microperca*).

169. **Roccus chrysops** (Rafinesque). (1557.) White bass.

Ohio River chiefly in the lower parts (Rafinesque 1820a, as *Perca chrysops*). Tennessee River near Paducah, and Cumberland River near Kuttawa, Ky. (Woolman, 1892).

170. **Aplodinotus grunniens** Rafinesque. (1900.) Fresh-water drum; lake sheepshead; "white perch" or "yellow perch."

Ohio River (Rafinesque, 1819, type). Tennessee and Cumberland Rivers (Rafinesque, 1820, as *Amblodon grunniens*). Ohio, Tennessee, Cumberland, and Kentucky Rivers (Rafinesque, 1820a, as *Amblodon grunniens*). Tennessee River near Huntsville, Ala. (Agassiz, 1854, as *Amblodon concinnus*, type). Tennessee River at Florence, Ala. (Gilbert and Swain, 1884, collectors). French Broad and Cumberland Rivers, Tenn. (Jordan, 1876). Abundant in the Tennessee Basin and in the channel of the Cumberland (Jordan and Brayton, 1878, as *Haplodinotus grunniens*). Rolling Fork of Salt River near Booth, Pond Creek near Rockport, Rough Creek near Hartford, Big Barren River near Bowling Green, Green River near Greensburg, Cumberland River near Kuttawa, Tennessee River near Paducah, Obion River near Cypress, and Bayou de Chien near Moscow, Ky. (Woolman, 1892). Smith Fork near Lancaster, Tenn., and Cumberland River near mouth of Willis Creek in Cumberland County, Ky. (Kirsch, 1893). Falls of the Ohio (Evermann, 1902).

171. **Cottus ictalops** (Rafinesque). (2335.) Miller's thumb; blob.

Spring Creek near Lexington, Ky. (Rafinesque, 1820, as *Pegadictis ictalops*, type). North Fork of the Holston near Saltville, Va. (Cope, 1869, as *Uranidea carolinæ*). Powell River, Tenn. (Jordan, 1876, as *Potamocottus carolinæ*). French Broad River in Madison County, N. C. (Cope, 1877a, as *Uranidea carolinæ*). Chickamauga River near Ringgold, Ga., Cave Spring Creek at Cumberland Gap, Holston and French Broad Rivers (Jordan and Brayton, 1878, as *Potamocottus meridionalis*). Cumberland River near Nashville, Tenn. (Jordan and Brayton, 1878, as *Potamocottus meridionalis*). Wolf Creek in Cocke County, Tenn., Tennessee River near Florence and Huntsville, and Clinch River at Clinton, Tenn. (Gilbert and Swain, 1884, collectors). North Fork of the Holston near Saltville, Middle Fork of the Holston near Marion and Glade Spring, South Fork of the Holston near Holstein Mills, Va., Watauga and Doe Rivers near Elizabethton, Tenn., Spring Creek at Hot Springs, and Swannanoa River near Asheville, N. C. (Jordan, 1889, as *Cottus bairdi*). Little Barren River near Osceola, Ky. (Woolman, 1892, as *Cottus bairdi*). Indian Creek near Cumberland Gap, Ball Creek near Tazewell, Tennessee River near Knoxville, Nolichucky River near Greenville, Arnwine Spring near Mount Verd, Eastaunaula and Norvel Spring Creeks near Athens, Nickajack Cave near Shellmound, Tenn., and Chickamauga Creek near Lee & Gordon's mill, Ga. (Evermann, Scovell, and Gurley, 1893, collectors; and Evermann and Hildebrand, 1916). Round Lick Creek near Watertown, Roaring River near Windle, Spring Creek at Springcreek station, and Obeys River near Olympus, Tenn., and Little South Fork of the Cumberland near mouth of Canada Creek, Ky. (Kirsch, 1893, as *Cottus bairdi*).

NOMINAL SPECIES.

Following is a list of the nominal species of fishes, arranged in chronological order, described as new from the Cumberland and Tennessee Basins or other waters of Kentucky and Tennessee. The list shows (1) the year, (2) the authority, (3) nominal species, (4) present identification, and (5) type locality.

Year.	Authority.	Nominal species.	Present identification.	Type locality.
1818	Rafinesque	Acipenser platorhynchus	Scaphirhynchus platorhynchus.	Ohio River.
1818	do	Bodianus calliurus	Micropterus dolomieu	Do.
1818	do	Catostomus erythrurus	Moxostoma aureolum	Do.
1818	do	Catostomus macropterus	(?)	Do.
1818	do	Catostomus duquesnei	Placopharynx duquesnii	Do.
1818	do	Clupea heterurus	Dorosoma cepedianum	Do.
1818	do	Clupea alosoides	Hiodon alosoides	Do.
1818	do	Glossodon harengoides	Hiodon tergisus	Do.
1818	do	Glossodon heterurus	do	Do.
1818	do	Hydrargyra dinema	Notropis atherinoides	Do.
1818	do	Hydrargyra notata	Pimephales notatus	Do.
1818	do	Hydrargyra amblops	Hybopsis amblops	Do.
1818	do	Lepisosteus fluviatilis	(?)	Do.
1818	do	Catostomus bubalus	Ictiobus bubalus	Do.
1818	do	Perca salmonea	Stizostedion vitreum	Do.
1818	do	Perca chrysops	Roccus chrysops	Do.
1818	do	Polyodon pristis	(?)	Do.
1818	do	Polyodon folium	Polyodon spathula	Do.
1818	do	Sciæna grunniens	Aplodinotus grunniens	Do.
1818	do	Sciæna caprodes	Percina caprodes	Do.
1818	do	Sparus cyanelus	Apomotis cyanellus	Do.
1818	do	Sparus nigropunctatus	Pomoxis annularis	Do.
1818	do	Silurus punctatus	Ictalurus punctatus	Do.
1818	do	Silurus amblodon	Leptops olivaris	Do.
1818	do	Silurus olivaris	do	Do.
1818	do	Silurus pallidus	Ictalurus punctatus	Do.
1818a	do	Accipenser heptitus	Acipenser rubicundus	Do.
1818a	do	Anguilla laticauda	Anguilla chrisypa	Do.
1818a	do	Bodianus calliops	Micropterus dolomieu	Do.
1818a	do	Catostomus amisopterus	(?)	Do.
1818a	do	Catostomus velifer	Carpiodes velifer	Do.
1818a	do	Catostomus amblodon	(?)	Do.
1818a	do	Cyprinus trachiaphas	(?)	Do.
1818a	do	Cyprinus fasciolaris	Erimyzon sucetta oblongus	Do.
1818a	do	Clupea chrysochloris	Pomolobus chrysochloris	Do.
1818a	do	Dinoctus truncatus	(?)	Do.
1818a	do	Esox vittatus	Lucius lucius	Do.
1818a	do	Exoglossum argentum	(?)	Do.
1818a	do	Esox fasciolaris	Lucius vermiculatus	Do.
1818a	do	Glanis limosus	Leptops olivaris	Do.
1818a	do	Glossodon chrysops	(?)	Do.
1818a	do	Lepisosteus platostomus	Lepisosteus platostomus	Do.
1818a	do	Lepisosteus stenorhynchus	(?)	Do.
1818a	do	Litholepis adamantinus	Lepisosteus tristœchus	Do.
1818a	do	Olmerus albus	(?)	Do.
1818a	do	Pogostoma leucops	(?)	Do.
1818a	do	Silurus cerulescens	Ictalurus punctatus	Do.
1818b	do	Exoglossum (Hypentelium) macropterum.	Hypentelium nigricans	Falls of the Ohio.
1818b	do	Pomoxis Annularis	Pomoxis annularis	Ohio River at the Falls.
1818b	do	Sarchirus Vittatus	Lepisosteus osseus	Lower parts of the Ohio.
1818c	do	Noturus flavus	Noturus flavus	Ohio River at the Falls.
1819	do	? Amblodon niger	Cycleptus elongatus	Ohio River.
1819	do	Amblodon bubalus	Ictiobus bubalus	Do.
1819	do	Etheostoma flabellaris	Etheostoma flabellare	Tributaries of the Ohio.
1819	do	Lepomis macrochira	Lepomis macrochirus	Ohio and Licking Rivers.
1819	do	Lepomis cyanellus	Apomotis cyanellus	Ohio River.
1819	do	Noturus lutius	Noturus flavus	Do.
1819	do	Notemigonus auratus	Abramis crysoleucas	Falls of the Ohio.
1820	do	Silurus viscosus	Leptops olivaris	Ohio River.
1820	do	Silurus lividus var. fuscatus.	Ameiurus natalis	Do.
1820	do	Silurus argyrus var. leucoptera.	Ictalurus punctatus	Do.
1820	do	Silurus argyrus var. lateralis.	do	Do.

Year.	Authority.	Nominal species.	Present identification.	Type locality.
1820	Rafinesque	Silurus argyrus var. marginatus.	Ictalurus punctatus	Ohio River.
1820	do.	Silurus argyrus var. erythroptera.	do.	Do.
1820	do.	Silurus argyrus	do.	Do.
1820	do.	Silurus argentinus	do.	Do.
1820	do.	Silurus maculatus	do.	Do.
1820	do.	Silurus melas	Ameiurus melas	Do.
1820a	do.	Accipenser serotimus	Acipenser rubicundus	Ohio and Kentucky Rivers.
1820a	do.	Accipenser ohiensis	do.	Ohio River as far up as Pittsburgh.
1820a	do.	Accipenser lagenarius	do.	Ohio River.
1820a	do.	Anguilla aterrima	Anguilla chrisypa	Tennessee and Cumberland Rivers, etc.
1820a	do.	Anguilla xanthomelas	do.	Ohio River as far up as Pittsburgh.
1820a	do.	Anguilla lutea	do.	Cumberland, Green, and Licking Rivers, etc.
1820a	do.	Catostomus flexuosus	Catostomus commersonii	Most common species in Kentucky; in all the streams and ponds.
1820a	do.	Catostomus melanotus	Campostoma anomalum	Falls of the Ohio.
1820a	do.	Catostomus melanops	Minytrema melanops	Do.
1820a	do.	Catostomus xanthopus	Hypentelium nigricans	Below the Falls of the Ohio.
1820a	do.	Catostomus carpio	Carpiodes carpio	Falls of the Ohio.
1820a	do.	Catostomus anisurus	Moxostoma anisurum	All over the Ohio and the larger streams as far as Pittsburgh.
1820a	do.	Cycleptus nigrescens	Cycleptus elongatus	Ohio River as far as Pittsburgh.
1820a	do.	Calliurus Punctulatuse	Micropterus dolomieu	Falls of the Ohio.
1820a	do.	Dorosoma notata	Dorosoma cepedianum	Do.
1820a	do.	Etheostoma Blennioides	Diplesion blennioides	Ohio River.
1820a	do.	Etheostoma nigra	Boleosoma nigrum	Green River.
1820a	do.	Etheostoma flabellata	Etheostoma flabellare	Falls of the Ohio.
1820a	do.	Etheostoma calliura	Micropterus dolomieu	Ohio and Salt Rivers, etc.
1820a	do.	Etheostoma fontinalis	Etheostoma flabellare	Springs and caves near Lexington, Ky.
1820a	do.	Esox salmoneus	Lucius ohiensis	Ohio River.
1820a	do.	Hyodon vernalis	Hiodon tergisus	All over the Ohio and even at Pittsburgh.
1820a	do.	Hyodon amphiodon	Hiodon alosoides	Lower parts of the Ohio.
1820a	do.	Icthelis melanops	Apomotis cyanellus	Tributary streams of the Ohio, Kentucky, and Licking Rivers.
1820a	do.	Icthelis enythrops	Ambloplites rupestris	No stream mentioned.
1820a	do.	Icthelis megalotis	Lepomis megalotis	Kentucky, Licking, and Sandy Rivers, etc.
1820a	do.	Lepisosteus ferox	Lepisosteus tristœchus	Lower parts of the Ohio.
1820a	do.	Lepisosteus oxyurus	Lepisosteus osseus	Ohio River.
1820a	do.	Lepisosteus albus	Lepisosteus platostomus	Do.
1820a	do.	Lepomis pallida	Micropterus salmoides	Do.
2820a	do.	Lepomis trifasciata	Micropterus dolomieu	Ohio River and many other streams.
1820a	do.	Lepomis flexuolaris	do.	Ohio and tributaries.
1820a	do.	Lepomis Salmonea	do.	Ohio, Kentucky, Green, and Licking Rivers, etc.
1820a	do.	Lepomis notata	do.	Do.
1820a	do.	Lepomis ictheloides	Ambloplites rupestris	Kentucky River and tributary streams.
1820a	do.	Luxilus or Chrosomus erythrogaster.	Chrosomus erythrogaster	Kentucky River.
1820a	do.	Luxilus chrysocephalus	Notropis cornutus	Ohio, Kentucky, Cumberland, and Green Rivers, etc.
1820a	do.	Luxilus Kentuckiensis	Hybopsis kentuckiensis	No stream mentioned.
1820a	do.	Luxilus interruptus	Notropis cornutus	Ohio River.
1820a	do.	Minnilus microstomus	? Notropis blennius	Kentucky River.
1820a	do.	Pimephales promelas	Pimephales promelas	Pond near Lexington, Ky.
1820a	do.	Petromyzon nigrum	Lampetra wilderi	Ohio River as far up as Pittsburgh.
1820a	do.	Rutilus plargyrus	Notropis cornutus	Streams of Kentucky.
1820a	do.	Rutilus Amblops	Hybopsis amblops	Falls of the Ohio.
1820a	do.	Rutilus melanurus	Moxostoma aureolum	Ohio River.
1820a	do.	Rutilus anomalus	Campostoma anomalum	Licking River, etc.
1820a	do.	Rutilus ruber	Notropis umbratilis lythrurus.	Small streams which fall into the Elkhorn and Kentucky.
1820a	do.	Semotilus dorsalis	Semotilus atromaculatus	In the Kentucky and several other rivers.
1820a	do.	Senotilus cephalus	do.	Creeks of Kentucky, etc.
1820a	do.	Semotilus diplemia	do.	Kentucky River near Estill.
1820a	do.	Semotilus ? notatus	Fundulus notatus	Cumberland River and Little River, a branch of it.
1832	do.	Pimelodus lutescens	Ictalurus punctatus	Tennessee River.
1845	Storer	Pœcilia olivacea	Fundulus notatus	Tennessee River at Florence, Ala.
1845	do.	Etheostoma tessellata	Etheostoma tessellatum	Do.
1845	do.	Leuciscus obesus	Notropis cornutus	Do.
1845	do.	Etheostoma cinerea	Etheostoma cinereum	Do.
1854	Agassiz	Hybopsis gracilis	Hybopsis amblops	Tennessee River near Huntsville, Ala.
1854	do.	Rhinichthys obtusus	Rhinichthys atronasus	Do.
1854	do.	Carpiodes Urus	Ictiobus urus	Do.
1854	do.	Esox crassus	Lucius reticulatus	Do.
1854	do.	Amblodon concinnus	Aplodinotus grunniens	Do.
1854	do.	Hyostoma Newmanii	Diplesion blennioides	Do.
1854	do.	Pomotis pallidus	Eupomotis pallidus	Do.
1854	do.	Pomotis bombifrons	Lepomis megalotis	Do.
1854	do.	Pomotis obscurus	Lepomis pallidus	Do.
1854	do.	Pomotis notatus	Eupomotis heros	Do.
1854	do.	Pomotis inscriptus	Lepomis megalotis	Do.
1854	do.	Pomotis sanguinolentus	do.	Do.
1854	do.	Grystes nobilis	Micropterus salmoides	Do.

Year.	Authority.	Nominal species.	Present identification.	Type locality.
1867	Cope	Phenacobius uranops	Phenacobius uranops	Holston River near Saltville, Va.
1867a	do	Photogenis leuciodus	Notropis leuciodus	"Tributaries of the Holston in situations similar to those where *P. telescopus* occurs."
1867a	do	Photogenis telescopus	Notropis telescopus	"Very abundant in all the rapid streams tributary to the Holston River in Virginia. It is very rare in the river itself."
1867a	do	Hypsilepis galacturus	Notropis galacturus	"Abundant in the tributaries of the Holston River in Virginia."
1867a	do	Hypsilepis coccogenis	Notropis coccogenis	"It occurs in abundance in the clear and often rapid creeks that flow into the north and middle forks of the Holston River in Virginia. Taken in the ninth month."
1869	do	Cottogaster aurantiacus	Hypohomus aurantiacus	North Fork of Holston River near Saltville, Va.
1869	do	Pœcilichthys zonalis	Etheostoma zonale	Do.
1869	do	Hyostoma blennioperca	Diplesion blennioides	"Common in the tributaries of the Kanawha and Holston."
1869	do	Hyostoma simoterum	Ulocentra simoterum	"One of the most abundant in the Holston River and its tributaries."
1869	do	Ceratichthys hyalinus	Hybopsis amblops	"Abundant in the tributaries of the Holston."
1869	do	Ceratichthys monacus	Hybopsis monacus	"Singly or in pairs in the channel of the Holston River, in Washington County, Va.
1869	do	Hybopsis spectrunculus	Notropis spectrunculus	"Abundant in Bear Creek, a tributary of the middle fork of the Holston River, in Smyth County, Va."
1869	do	Hybopsis rubricroceus	Notropis rubricroceus	"Bear Creek, a tributary of the middle fork of the Holston, also near mouth of Tumbling Fork of the North Fork of the Holston."
1869	do	Hybopsis lacertosus	Notropis lacertosus	Bear Creek, a tributary of the middle fork of the Holston River, Va.
1869	do	Alburnellus micropteryx	Notropis micropteryx	Holston River.
1870	do	Pœcilichthys rufilineatus	Etheostoma rufilieatum	Warm Springs Creek in Madison County, N. C.
1870	do	Pœcilichthys vulneratus	Etheostoma vulneratum	Do.
1870	do	Pœcilichthys camurus	Etheostoma camurum	Headwaters of the Cumberland in Tennessee.
1870	do	Pœcilichthys sanguifluus	Etheostoma maculatum	Headwaters of South Fork of the Cumberland in Tennessee.
1870	Duméril	Acipenser (Antaceus) Cincinnati.	Acipenser rubicundus	Ohio River at Cincinnati.
1870	do	Acipenser (Huso) Rafinesquii.	do	Ohio River.
1870	do	Acipenser (Huso) paranasimos.	do	Tennessee River near Huntsville, Ala.
1872	Putnam	Chologaster agassizii	Chologaster agassizii	Well in Lebanon, Tenn.
1877	Jordan	Noturus eleutherus	Schilbeodes eleutherus	Big Pigeon River, Newport, Tenn.
1877a	do	Hyodon selenops	Hiodon selenops	Tennessee River at Chattanooga, and Cumberland River.
1877a	do	Etheostoma squamiceps	Etheostoma squamiceps	Russellville, Ky.
1877a	do	Arlina atripinnis	Ulocentra simotera	Tributary of Cumberland River near Nashville, Tenn.
1877	Jordan and Brayton.	Lagochila lacera	Lagochila lacera	Chickamauga Creek near Ringgold, Ga.
1878	Jordan	Pœcilichthys jessiæ Jordan and Brayton.	Etheostoma jessiæ	Do.
1878	do	Phoxinus flammeus	Leuciscus flammeus	Elk River at Estill Springs.
1878	do	Gila estor	Leuciscus vandoisulus	Elk River at Estill Springs, and Stone River at Murfreesboro, Tenn.
1883	Jordan and Swain.	Etheostoma cumberlandicum.	Etheostoma flabellare cumberlandicum.	"Excessively abundant in all the small streams of the Cumberland Mountains. Numerous examples were taken in Wolf Creek, Briar Creek, etc. Others seen in Clear Fork, Yellow Creek, Gap Creek, etc."
1883	do	Pœcilichthys sagitta	Etheostoma sagitta	Wolf Creek, Whitley County, Ky.
1883	do	Boleosoma susanæ	Boleosoma susanæ	"Abundant in the tributaries of the Clear Fork of the Cumberland. Most of the numerous types from Wolf Creek."
1887	Gilbert and Swain.	Etheostoma (Etheostoma) tuscumbia.	Etheostoma tuscumbia	Spring Creek at Tuscumbia, Ala.
1887	do	Etheostoma (Etheostoma) luteovinctum.	Etheostoma luteovinctum.	Stone River near Nashville, Tenn.
1887	do	Etheostoma (Rhothœca) blennius.	Etheostoma blennius	Cox and Shoal Creeks near Florence, Ala.
1887	Gilbert	Etheostoma nianguæ spilotum.	Etheostoma spilotum	Sturgeon Creek near Travelers Rest, Owsley County, Ky.
1887	do	Etheostoma (Etheostoma) squamatus.	Etheostoma squamatus	French Broad River at the mouth of Wolf Creek, Tenn.
1888a	Jordan	Etheostoma swannanoa Jordan and Evermann.	Etheostoma swannanoa	South Fork of the Swannanoa at Black Mountain, N. C.; South Fork of the Holston at Holstein Mills, Va.; and Middle Fork of the Holston at Marion, Va.

Year.	Authority.	Nominal species.	Present identification.	Type locality.
1888a	Jordan	Hybopsis watauga Jordan and Evermann.	Hybopsis watauga	Watauga River near Elizabethton, Tenn., and North Fork of Holston River at Saltville, Va.
1889	Henshall	Etheostoma formosa	Etheostoma cœruleum	Small tributary of Tennessee River near Whiteside, Tenn.
1889	.....do	Etheostoma duryi	Ulocentra simotera	Do.
1891	Gilbert	Notropis umbratilis fasciolaris.	Notropis umbratilis fasciolaris.	Pin-hook and Spring Creeks near Huntsville, Ala.; Veta Wright Creek near Decatur, Ala.; Mallett Creek near Hillsbor, Ala.; Big Nance Creek at Courtland, Ala.; Spring Creek at Tuscumbia, Ala.; and Cypress Creek at Florence, Ala.
1892	Kirsch	Etheostoma obeyense	Etheostoma obeyense	Indian, Spring, and Smith Creeks and Albany Branch, Clinton County, Ky.
1896	Jordan and Evermann.	Ulocentra meadiæ	Ulocentra meadiæ	Indian Creek near Cumberland Gap, Tenn.
1896	.....do	Ulocentra gilberti Evermann and Thoburn.	Ulocentra gilberti	Clinch River at Walkers Ford, Tenn.
1896	.....do	Catostomus rhothœcus Evermann and Thoburn.	Catostomus rhothœcus	Probably French Broad River at Wolf Creek, Tenn.
1902	Evermann	Alosa ohiensis	Alosa ohiensis	Falls of the Ohio.

The above table shows that 191 nominal species of fishes have been described from the Cumberland and Tennessee River Basins and other waters in Kentucky and Tennessee. Of this number 77 are at present regarded as good species. Thus, of the total of 171 species admitted as constituting the fish fauna of Kentucky and Tennessee, only 77 were originally described from those waters and 94 from other waters.

The following table gives (1) the names of the ichthyologists who have described supposedly new species from Kentucky and Tennessee, (2) the number of species described by each, (3) the number of his nominal species now accepted as good, and (4) the number not accepted:

Authority.	Number of species described from Kentucky and Tennessee.	Number accepted as good species.	Number regarded as synonyms.
Rafinesque	125	34	91
Cope	19	16	3
Agassiz	13	2	11
Jordan	6	4	2
Storer	4	2	2
Jordan and Evermann	4	4	0
Duméril	3	0	3
Jordan and Swain	3	3	0
Gilbert	3	3	0
Gilbert and Swain	3	3	0
Henshall	2		2
Putnam	1	0	0
Jordan and Brayton	2	1	0
Kirsch	1	2	0
Evermann and Thoburn	1	1	0
Evermann	1	1	0
Total	191	77	114

FISHES OF KENTUCKY AND TENNESSEE, BY PRINCIPAL RIVER SYSTEMS.

Names of species.	Lower Tennessee Basin.	Upper Tennessee Basin.	Lower Cumberland Basin.	Upper Cumberland Basin.	Green River Basin.	Salt River Basin.	Kentucky River Basin.	Licking River Basin.	Little Sandy River Basin.	Big Sandy River Basin.	Obion River Basin.	Bayou de Chien.	Recorded only from the Ohio River in italics.
Ichthyomyzon concolor		×											
Lampetra wilderi													*X*
Polyodon spatula	×	×	×	×									×
Acipenser rubicundus	×	×	×										×
Scaphirhynchus platorhynchus													*X*
Lepisosteus osseus	×	×	×	×	×			×	×		×		×
Lepisosteus platostomus	×	×	×										
Lepisosteus tristœchus													*X*
Amia calva		×											
Ictalurus furcatus		×											×
Ictalurus punctatus	×	×	×	×	×	×	×	×	×		×	×	×
Ictalurus anguilla													*X*
Ameiurus lacustris			×										
Ameiurus natalis		×	×	×	×								×
Ameiurus nebulosus			×	×	×							×	×
Ameiurus melas							×						×
Leptops olivaris	×	×	×	×	×	×	×						×
Noturus flavus		×						×					×
Schilbeodes gyrinus					×							×	
Schilbeodes eleutherus		×	×		×								
Schilbeodes miurus	×	×			×	×	×		×	×			
Ictiobus cyprinella			×										
Ictiobus urus		×											
Ictiobus bubalus	×		×	×	×							×	×
Carpiodes carpio	×	×				×							×
Carpiodes difformis			×						×	×	×		
Carpiodes velifer	×						×		×	×	×	×	×
Cycleptus elongatus			×										×
Catostomus rhothœcus		×											
Catostomus commersonii	×	×	×	×	×	×	×						
Hypentelium nigricans	×	×	×	×	×	×	×	×		×	×		×
Erimyzon sucetta	×	×	×	×			×						
Erimyzon sucetta oblongus			×				×						
Minytrema melanops	×	×	×	×	×								×
Moxostoma anisurum		×		×					×				×
Moxostoma aureolum	×	×	×	×	×	×	×	×	×	×		×	×
Moxostoma breviceps									×				
Placopharynx duquesnii		×											×
Lagochila lacera	×	×		×	×								
Campostoma anomalum	×	×	×	×	×	×	×	×	×	×			×
Chrosomus erythrogaster	×	×	×	×	×		×						
Hybognathus nuchale	×	×	×		×				×	×	×	×	
Pimephales promelas			×				×						
Pimephales notatus	×	×	×	×	×	×	×	×	×	×	×	×	×
Semotilus atromaculatus		×	×	×	×	×	×			×			
Leuciscus vandoisulus	×	×	×	×									
Leuciscus flammeus		×	×	×									
Opsopœdus emiliæ			×									×	
Opsopœodus bollmani											×		
Abramis crysoleucas	×		×				×					×	×
Cliola vigilax	×		×			×			×	×			
Notropis blennius	×	×	×	×	×	×	×	×	×	×	×		
Notropis spectrunculus		×		×			×						
Notropis shumardi		×	×										
Notropis whipplii	×	×	×	×	×	×	×	×	×	×		×	
Notropis galacturus		×	×	×									
Notropis cornutus	×	×	×	×	×	×	×	×	×	×	×	×	×
Notropis lacertosus		×											
Notropis coccogenis		×								×			
Notropis zonatus		×											
Notropis rubricroceus		×											
Notropis ariommus		×			×	×	×			×			
Notropis jejunus			×						×	×	×		
Notropis leuciodus		×	×										
Notropis telescopus	×	×	×	×	×								
Notropis stilbius		×											
Notropis atherinoides		×	×	×	×	×	×	×	×	×	×	×	×
Notropis arge					×	×							
Notropis dilectus		×		×	×		×	×	×	×			
Notropis photogenis		×											
Notropis micropteryx	×	×	×	×									
Notropis liris	×	×											
Notropis umbratilis lythrurus			×	×	×	×	×				×		
Notropis umbratilis fasciolaris		×											
Ericymba buccata			×	×		×	×	×	×	×			

FISHES OF KENTUCKY AND TENNESSEE, BY PRINCIPAL RIVER SYSTEMS—Continued.

Names of species.	Lower Tennessee Basin.	Upper Tennessee Basin.	Lower Cumberland Basin.	Upper Cumberland Basin.	Green River Basin.	Salt River Basin.	Kentucky River Basin.	Licking River Basin.	Little Sandy River Basin.	Big Sandy River Basin.	Obion River Basin.	Bayou de Chien.	Recorded only from the Ohio River in italics.
Phenacobius mirabilis			×										
Phenacobius uranops	×	×	×	×	×								
Rhinichthys cataractæ		×											
Rhinichthys atronasus	×	×	×										
Hybopsis hyostomus	×		×		×			×		×			
Hybopsis monacus	×	×											
Hybopsis dissimilis	×	×	×			×							
Hybopsis watauga		×			×		×						
Hybopsis amblops		×	×	×	×	×	×	×		×			×
Hybopsis storerianus	×		×		×	×			×			×	×
Hybopsis kentuckiensis	×	×	×	×	×		×	×		×			×
Anguilla chrisypa			×	×	×			×				×	
Hiodon alosoides			×			×							×
Hiodon tergisus				×									×
Hiodon selenops				×	×	×							
Dorosoma cepedianum	×		×		×	×			×	×	×	×	×
Pomolobus chrysochloris	×		×						×				×
Salvelinus fontinalis		×											
Lucius vermiculatus		×						×			×	×	
Lucius lucius													*X*
Fundulus catenatus		×	×	×	×								
Fundulus notatus		×	×	×	×	×					×	×	
Gambusia affinis			×								×		
Typhlichthys subterraneus		×		×	×								
Chologaster agassizii			×										
Amblyopsis spelæus					×								
Aphredoderus sayanus		×			×		×				×	×	
Labidesthes sicculus	×	×	×		×		×	×	×	×	×	×	
Pomoxis annularis		×		×	×				×		×	×	×
Pomoxis sparoides			×								×	×	
Centrarchus macropterus[a]													
Ambloplites rupestris	×	×	×	×	×	×	×	×	×	×			×
Chænobryttus gulosus	×	×				×					×	×	
Apomotis cyanellus		×	×		×		×	×		×			×
Lepomis auritus[b]													
Lepomis garmani				×								×	
Lepomis megalotis		×	×	×	×	×	×	×	×	×	×	×	
Lepomis macrochirus			×	×	×			×			×		×
Lepomis pallidus	×	×	×	×	×			×	×	×		×	
Eupomotis pallidus		×											
Eupomotis heros	×	×										×	
Micropterus dolomieu	×	×	×	×	×	×	×	×	×	×	×	×	×
Micropterus salmoides	×	×	×	×	×		×	×	×	×	×	×	×
Stizostedion vitreum	×	×	×	×	×		×	×	×	×			×
Stizostedion canadense		×	×						×	×			
Percina caprodes	×	×	×	×	×	×	×	×			×	×	×
Hadropterus phoxocephalus	×	×	×	×	×	×				×			
Hadropterus macrocephalus		×		×	×					×			
Hadropterus maculatus		×	×	×									
Hadropterus aspro		×	×	×	×		×			×	×	×	
Hadropterus ouachitæ					×						×		
Hadropterus evides	×	×			×								
Hadropterus scierus		×			×		×		×				
Hypohomus squamatus		×											
Hypohomus aurantiacus		×											
Hypohomus cymatotænia					×								
Hypohomus spilotus							×						
Cottogaster copelandi	×	×			×								
Cottogaster shumardi			×		×						×		
Ulocentra meadiæ		×											
Ulocentra stigmæa		×	×		×								
Ulocentra gilberti		×											
Ulocentra veracunda		×											
Ulocentra histrio					×								
Ulocentra simotera	×	×	×	×	×		×						
Diplesion blennioides	×	×	×	×	×	×	×	×		×			×
Boleosoma nigrum	×	×	×	×	×		×	×	×	×		×	
Boleosoma susanæ				×									
Crystallaria asprella					×								×
Ammocrypta pellucida		×	×	×	×	×	×		×	×			
Etheostoma variatum				×			×	×					×
Etheostoma swannanoa		×											
Etheostoma blennius		×											

[a] Recorded only from Mayfield Creek near Hickory Grove, Ky. Identification doubtful.
[b] Rivers, creeks, and ponds of Kentucky (Rafinesque).

FISHES OF KENTUCKY AND TENNESSEE, BY PRINCIPAL RIVER SYSTEMS—Continued.

Names of species.	Lower Tennessee Basin.	Upper Tennessee Basin.	Lower Cumberland Basin.	Upper Cumberland Basin.	Green River Basin.	Salt River Basin.	Kentucky River Basin.	Licking River Basin.	Little Sandy River Basin.	Big Sandy River Basin.	Obion River Basin.	Bayou de Chien.	Recorded only from the Ohio River in italics.
Etheostoma rupestre		×											
Etheostoma zonale		×	×	×	×	×	×	×	×	×			
Etheostoma camurum		×	×	×	×								
Etheostoma vulneratum		×											
Etheostoma maculatum		×	×	×				×					
Etheostoma cinereum		×	×										
Etheostoma tessellatum		×											
Etheostoma rufilineatum		×	×		×								
Etheostoma sagitta				×									
Etheostoma jessiæ		×											
Etheostoma luteovinctum			×										
Etheostoma cœruleum	×	×	×	×	×	×	×	×		×			
Etheostoma obeyense			×										
Etheostoma virgatum			×	×	×								
Etheostoma squamiceps		×	×		×								
Etheostoma flabellare		×	×	×	×		×	×		×			×
Etheostoma flabellare cumberlandicum				×									
Psychromaster tuscumbia		×											
Boleichthys fusiforme												×	
Microperca punctulata					×								
Roccus chrysops	×		×										×
Aplodinotus grunniens	×	×	×		×	×	×				×	×	×
Cottus ictalops		×	×		×		×						
Total	56	113	94	68	79	37	50	35	35	41	31	34	50

THE DECAPOD CRUSTACEANS OF BEAUFORT, N. C., AND THE SURROUNDING REGION

⁂

By W. P. Hay and C. A. Shore

⁂

Contribution from the United States Fisheries Biological Station, Beaufort, N. C.

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INTRODUCTION.

The following report on the decapod crustaceans of the region surrounding Beaufort, N. C., was begun by the junior author in 1904, while a student in the University of North Carolina, and was worked on actively for three years. During that time the crustacean material which had accumulated at the United States fisheries laboratory was studied and identified, much collecting was done and descriptions of most of the species known to occur in the region were prepared for publication. An extensive series of photographs was also made for the purpose of illustrating the paper.

At this point other duties intervened and made it necessary to permanently abandon all hope of completing the report.

In 1912 the senior author took up the work. It was hoped at first to bring the paper to an early conclusion, but it soon became evident that several seasons' work would be required to produce a satisfactory result. The nomenclature and synonymy of the species already described had to be brought up to date, the rather extensive collections of five or six years had to be worked over, and numerous additional descriptions and photographs had to be prepared. As the work progressed it became clearly evident that the needs of the student of crustaceans would be best served by the preparation of entirely new and uniform descriptions of all the species. Although this involved the rewriting of all the descriptions of the junior author and the preparation of a new series of photographs, the task was undertaken and pushed forward as rapidly as other duties would permit. It is now brought to a conclusion with the belief that future collecting will add but few species to the list.

The growth of our knowledge of the crustacean fauna of the Beaufort region has been slow and extends over many years. The first collector, of whose work we have a record, was William Stimpson, who visited Beaufort, in company with T. N. Gill, in 1860. In his brief account of this trip[a] he gives a list of 38 species of decapod crustaceans which he had collected. In 1871 Elliott Coues, at that time an Army surgeon, stationed at Fort Macon, published the second of his "Notes on the fauna of Fort Macon, N. C., and vicinity (No. 2)"[b] which included a list of 27 species of decapods,

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[a] Amer. Jour. Sciences and Arts, series 2, vol. XXIX, p. 442–445. 1860.

[b] Proc. Acad. Nat. Sci. Phil., vol. XXIII, p. 120–124. 1871.

8 of which were additions to Stimpson's list. Seven years later Coues and Yarrow, in the fifth installment of "Notes on the fauna of Fort Macon, N. C., and vicinity (No. 5)"[a] gave a short list of 6 species, 2 of which had not appeared in any previous list. An appendix to the same paper, by J. S. Kingsley, entitled "A list of the decapod crustaceans of the Atlantic coast whose range embraces Fort Macon,"[b] included 63 species, of which 51 were definitely credited to Beaufort or Fort Macon and 3 were additions to the fauna. A year later the same author published a paper under the title, "On a collection of crustaceans from Virginia, North Carolina, and Florida, with a revision of the genera of Crangonidæ and Palæmonidæ"[c] in which he mentions 36 species as having come from Beaufort or Fort Macon. Of these, 8 were new records.

The collection which was the subject of Kingsley's report had been made by Prof. H. E. Webster, of Union College. It was later transferred, in part at least, to the United States National Museum and supplied the types of *Lepidopa websteri* Benedict and *Pinnixa cristata* Rathbun, both of which were collected near Beaufort.

During the years that Johns Hopkins University maintained its seaside laboratory at Beaufort, the crustaceans were studied by Dr. Brooks and a number of his students. A great deal was added to the knowledge of the habits and development of some of the species, but only one or two new ones were added to the fauna.[d]

The manuscript of the junior author included 87 species, but he omitted 8 which had been listed by the writers already mentioned. His additions to the fauna were 33 species, making a total of 95 species for the Beaufort region.

The careful and systematic survey of the offshore fishing banks by the steamer *Fish Hawk* during the summers of 1914 and 1915, energetic shore and shallow water collecting by parties from the laboratory and the inclusion of the fresh-water species of the region have enabled the senior author to add 57 species to those already known, and the detection by Dr. Mary J. Rathbun of a hitherto unknown species of *Parapinnixa* brings the total to 153.

The status of some of these species may justly be questioned, but it has been thought advisable to include all that have been reported from the region and all which, from what is known of their habits and distribution, are reasonably certain, sooner or later, to fall into the hands of the collector. There are also included several species which are perhaps, strictly speaking, deep-water forms ranging well beyond the 50-fathom line. In nearly all cases, however, they are represented in our collections by specimens from shallower water or are known to enter shallower water in localities not far to the north or to the south. The report thus becomes virtually a descriptive list of the decapod crustaceans of the Middle Atlantic coast, and, to a large measure, fills the gap between the various lists of New England, New York, and New Jersey crustaceans, and the Porto Rican fauna described by Dr. Mary J. Rathbun. It includes a large proportion of the species whose northern limit of distribution has been supposed to be in the neighborhood of Charleston, S. C., together with many that, up to the present, have not been known north of Florida or the West Indies.

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[a] Proc. Acad. Nat Sci. Phil., vol. xxx, p. 297–315. 1878.

[b] Ibid., p. 316–330.

[c] Proc. Acad. Nat. Sci. Phil., vol. xxxi, p. 383–427, pl. 14. 1879.

[d] *Stenopus hispidus*, the larval form of which was reported by Brooks and Herrick (Mem. Nat. Acad. Sci., v, 339–352) is not included in the present paper. The adult has not been collected north of the Bahamas.

The general aspect of the decapod fauna of the Beaufort region is subtropical. Unquestionably the great influx of species have been from the south, and the comparatively few northern ones that occur are evidently at a disadvantage. The Gulf Stream sweeping up along the coast at no great distance from the shore has doubtless been the route by which numerous crustaceans, often in the larval stages, have come northward. Some of these have been able to establish themselves while others are more or less regularly replaced by new individuals as the old ones are killed during the colder months of the year. The offshore fishing banks [a] offer peculiarly favorable conditions for the life of these tropical species of crustaceans, and of fishes, echinoderms, cœlenterates, and sponges as well, and have yielded some 30 species of decapods which have rarely, if ever, been taken closer to the shore.

The Gulf Stream and the prevailing south and southeast winds bring to the region, and often into the harbor, great quantities of drifting *Sargassum* among which large numbers of the smaller pelagic crabs and shrimps have taken shelter. In nearly all cases, the females of these species are laden with eggs, but it is probable that few if any of these survive the journey into the shallower and quieter waters along the coast. Some of the pelagic species, however, are so constant in their occurrence and their larval forms are so frequently met with that it is evident that they breed at no great distance from, if not within, the region.

For the truly local fauna, comprising the species that are firmly established and which can readily be obtained by ordinary methods of collecting, the shallow waters of the sounds and Beaufort Harbor, with their broad expanses of sand and mud flats, and the salt marshes which extend for miles along their margins offer an ideal home. The shrimps and swimming crabs are found in abundance in the deeper waters or among the eel grass near the marshes. Mud crabs and various burrowing species occur on the muddy bottoms, and myriads of fiddler crabs are to be seen on the mud flats along the margin of the marshes at low tide. In certain parts of the harbor there are areas of shelly bottom of considerable extent, and it is in such places that shrimps of the genus *Sicyonia* and crabs of the genera *Lithadia*, *Spelæophorus* and *Heterocrypta* occur. On the sandy bottoms the purse crabs (*Persephona*) and the box crabs (*Hepatus*) are occasionally found along with numbers of lady crabs (*Ovalipes*) and blue crabs, both *Callinectes sapidus* and *C. ornatus*. The sand flats, especially if there is an admixture of mud, are good collecting grounds for the burrowing and commensal species such as *Upogebia affinis*, *Polyonyx macrocheles*, and the various species of *Pinnixa*. Among the beds of oyster shells *Upogebia* and the species of *Crangon* are to be found. The sandy shores support such species as *Emerita talpoida*, *Albunea gibbesii*, and *Arenæus cribrarius*. These same shores, but in their higher levels, are inhabited by great numbers of the sand crabs (*Ocypode albicans*) whose curious appearance is certain to command the attention of even the most unobservant visitor and whose fleetness of foot will astonish him. About the rock jetties and the wharves the agile wharf crabs (*Sesarma cinerea*) are always in evidence. The fresh waters of the region have been very inadequately explored but it may safely be said that not more than the three species of crawfishes and one species of shrimp described in this paper will be found there.

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[a] The location and character of these banks have been described by Radcliffe, Bureau of Fisheries, Economic Circular No. 8.

In questions of nomenclature the authors have adhered rigidly to the "Code of Nomenclature" of the American Ornithologists' Union.

As is usual in papers of this nature, the synonymies of this paper have proved to be one of the most difficult and laborious parts of its preparation. It has been found impracticable to include citations to all the literature, but such citations as are given have been carefully verified and a conscientious effort has been made to include all that may be of value and to exclude all that have no special bearing on the question at hand.

The classification adopted is that of Borradaile [a] and the characters of the families, suborders, and tribes have been taken almost bodily from his paper. The sequence of families and genera follows the one adopted by the United States National Museum.

As far as possible the important diagnostic characters of the families and genera have been incorporated in the keys and are often repeated, in part, in the species descriptions. In addition to this, because of the somewhat new classification that has been adopted, brief diagnoses of the families and higher groups have been included in the body of the paper. It has not been thought necessary to include diagnoses of the genera as most of these have been sufficiently defined in Dr. Rathbun's report on the Brachyura and Macrura of Porto Rico, a paper which should be in the hands of anyone who attempts to work with the decapod crustaceans of our southern coast.

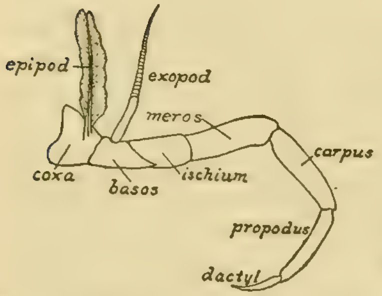

FIG. 1.—A crustacean leg showing epipod and exopod.

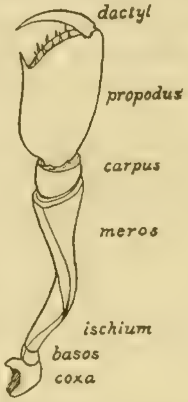

FIG. 2.—A subchelate limb of a crustacean.

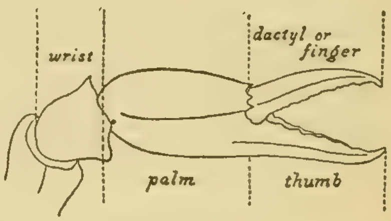

FIG. 3.—Chela of a crab.

Throughout the progress of their work, both authors have received the assistance of their associates in the Beaufort laboratory and the permanent force at the station on occasions too numerous and in ways too varied to be itemized. It is a pleasure, however, to acknowledge the many evidences of friendly interest that have been shown. In a more definite manner we are under many obligations to the Division of Marine Invertebrates of the United States National Museum, where Dr. Mary J. Rathbun, Dr. J. E. Benedict, and Mr. Waldo L. Schmitt have given us invaluable assistance. Through their kindness it has been possible to compare our materials with the accurately labeled specimens in the National Museum, to consult literature that otherwise would have been obtained only with great difficulty, and to obtain a final settlement of numerous perplexing questions of identification and nomenclature.

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[a] Annals and Magazine of Natural History, ser. 7, vol. XIX, p. 457-486. 1907.

KEY TO THE FAMILIES OF DECAPOD CRUSTACEANS WHICH ARE REPRESENTED IN THE BEAUFORT REGION.

a. General form shrimplike—the abdomen well developed and, usually, with the cephalothorax also, compressed; pleopods always present in full number and used for swimming. . (Suborder *Natantia*).

b. Pleura of second segment of abdomen not overlapping those of the first segment. . (Tribe *Peneidea*).

c. First three pairs of legs chelate; all of the legs well developed...... Family PENEIDÆ (p. 377).

cc. None of the legs chelate; last two pairs of legs small or wanting.... Family SERGESTIDÆ (p. 381).

bb. Pleura of second segment of abdomen overlapping those of the first segment.... (Tribe *Caridea*).

c. Carpus of second pair of legs subdivided into two or more articles.

d. Eyestalks short and usually covered by the carapace; first pair of legs stronger than the second pair.. Family CRANGONIDÆ (p. 382).

dd. Eyestalks of medium length or long, not covered by the carapace; first pair of legs not stronger than the second pair.

e. Rostrum small or wanting; eyestalks very long and slender; first two pairs of legs subequal.. Family OGYRIDÆ (p. 388).

ee. Rostrum well developed; eyestalks not abnormally lengthened; second pair of legs usually longer or stronger than first pair........................ Family HIPPOLYTIDÆ (p. 390).

cc. Carpus of second pair of legs not subdivided.

d. Rostrum well developed and compressed; first pair of legs not subchelate.

e. Third pair of maxillipeds pediform; body slender......... Family PALÆMONIDÆ (p. 392).

ee. Third pair of maxillipeds very broad; body short and thick. Family GNATHOPHYLLIDÆ (p. 395).

dd. Rostrum short; not compressed; first pair of legs subchelate..... Family CRAGONIDÆ (p. 396).

aa. General form lobsterlike or crablike—the abdomen may be well developed or greatly reduced in size, but in either case it, and, usually, the cephalothorax also is depressed; pleopods reduced or absent, not used for swimming.. (Suborder *Reptantia*).

b. Abdomen extended, symmetrical, well armored, with well-developed pleura and broad tail fin; third pair of legs like the first, either chelate or simple; branchiæ numerous.

c. Rostrum small or wanting; exopodites of uropods not sharply divided into two parts (Section *Palinura*).

d. Body subcylindrical; antennæ with strongly developed flagella. . Family PALINURIDÆ (p. 398).

dd. Body strongly depressed; antennæ short, squamiform........ Family SCYLLARIDÆ (p. 398).

cc. Rostrum well developed; exopodites of uropods divided into two parts by a suture (Section *Astacura*).

d. Marine species; last segment of thorax coalesced with the one in front of it Family HOMARIDÆ (p. 399).

dd. Fresh-water species; last segment of thorax not coalesced with the one in front of it.. Family ASTACIDÆ (p. 400).

bb. Abdomen bent upon itself or flexed beneath the thorax, or, rarely, soft and extended; pleura usually small or wanting; third pair of legs unlike the first, never chelate; branchiæ usually few.

c. Uropods usually present, often reduced in size, sometimes united with the telson; last thoracic sternum free; carapace not fused with the epistome.................... (Section *Anomura*).

d. Abdomen well developed.

e. Abdomen symmetrical; tail fan well developed.

f. Abdomen more or less flexed beneath the thorax; body depressed. . Tribe *Galatheidea*.

g. Form somewhat lobsterlike; rostrum well developed... Family GALATHEIDÆ (p. 401).

gg. Form crablike; rostrum short and broad or wanting. Family PORCELLANIDÆ (p. 403).

ff. Abdomen extended, more or less membranous; cephalothorax compressed (Tribe *Thalassinidea*).................................... Family CALLIANASSIDÆ (p. 406).

ee. Abdomen unsymmetrical; tail fan reduced and adapted for holding the body in hollow objects. (Tribe *Paguridea*)............................ Family PAGURIDÆ (p. 408).

dd. Abdomen much reduced in size and flexed under the thorax; tail fan not adapted for swimming; rostrum small or wanting.................................. (Tribe *Hippidea*).

e. First pair of legs simple; carapace subcylindrical............. Family HIPPIDÆ (p. 416).

ee. First pair of legs subchelate; carapace depressed........... Family ALBUNEIDÆ (p. 414).

cc. Uropods rarely present, never biramous; abdomen small and permanently flexed beneath the thorax; first pair of legs always chelate or subchelate............... (Section *Brachyura*).

d. Buccal frame roughly quadrate.
e. Last pair of legs modified in form and dorsal in position; openings of oviducts on coxopodites; first pleopods present in the female............................(Tribe *Dromiacea*).
f. Eyes completely sheltered by orbits........................Family Dromiidæ (p. 417).
ff. Eyes not sheltered by orbits.
g. Legs of moderate length; gills 13 or 14 on each side.....Family Homolidæ (p. 419).
gg. Legs excessively long and slender; gills 8 on each side. Family Latreillidæ (p. 419).
ee. Last pair of legs normal in form and position; openings of oviducts on the sternum; first pleopods wanting in the female..................................(Tribe *Brachygnatha*).
f. Body of medium width or broad in front; rostrum reduced or wanting; orbits well formed ....(Subtribe *Brachyrhyncha*).
g. Free-living crabs with well-developed eyes and firm, hard carapace.
h. Carapace broad, short, rounded anteriorly.
i. Distal articles of last pair of legs broad and thin, paddlelike...................... ....Family Portunidæ (p. 426).
ii. Distal articles of last pair of legs not paddlelike.
j. Antennules folding longitudinally; outer maxillipeds long, overlapping the epistome...Family Cancridæ (p. 434).
jj. Antennules folding transversely or obliquely transversely; outer maxillipeds usually not overlapping the epistome.
k. Body usually transversely oval.................Family Xanthidæ (p. 435).
kk. Body usually square or squarish.............Family Gonoplacidæ (p. 442).
hh. Carapace more or less quadrilateral; frontal region curved downward.
i. Front broad, eyestalks of moderate length or short....Family Grapsidæ (p. 447).
ii. Front of moderate width or narrow; eyestalks often very long................. ....Family Ocypodidæ (p. 450).
gg. Small commensal crabs with very small eyes and orbits; carapace usually more or less membranous....................................Family Pinnotheridæ (p. 442).
ff. Body narrowed in front; rostrum usually distinct; orbits usually incomplete........... ....(Subtribe *Oxyrhyncha*).
g. Chelipeds not a great deal larger than the other legs........Family Inachidæ (p. 452).
gg. Chelipeds much larger than any of the other legs......Family Parthenopidæ (p. 461).
dd. Buccal frame triangular, produced over the epistome..............(Tribe *Oxystomata*).
e. First pair of legs chelate; body and legs normal; antennæ small.
f. Front of body not specially produced and upturned; eyes of normal size; maxillipeds more nearly horizontal................................Family Calappidæ (p. 420).
ff. Front of body produced into a projecting, upturned mass bearing the small eyes close together and closed in front by the more nearly vertical maxillipeds................. ....Family Leucosiidæ (p. 423).
ee. First pair of legs subchelate; body more or less abnormal in shape; last one or two pairs of legs more dorsal than the others; antennæ large............Family Raninidæ (p. 420).

Suborder NATANTIA.

Decapod crustaceans of a shrimplike form having the abdomen strongly developed and compressed, with its first segment little, if any, smaller than the others and with five pairs of well-developed pleopods which are used for swimming. The cephalothorax is usually also compressed and the legs are slender except that any one of the first three pairs may be robust and chelate. Podobranchia are rarely present on the first three pairs of legs and never on the last two pairs. The rostrum is usually strongly developed and compressed.

This important suborder, which comprises 185 genera, is divided into 3 tribes, of which 2 are represented in the Beaufort fauna.

Tribe PENEIDEA.

Natantia having the third pair of legs chelate but not stouter than the two preceding pairs, the pleura of the first abdominal segment not overlapped by those of the second, the abdomen without a sharp bend and the first abdominal appendages of the male with a sexual apparatus. The gills are never developed as phyllobranchiæ.

This tribe comprises 2 families, both of which have representatives in the Beaufort fauna.

Family PENEIDAE.

Peneidea having the last two pairs of legs well developed and the gills numerous.

This family comprises 23 genera, of which 4 are represented in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Integument thin; abdomen smooth, not carinate anteriorly; trunk legs with exopodites; pleopods biramous........(Subfamily *Peneinæ*).
  b. Endopodite of first maxilla elongate and segmented........*Peneus*.
  bb. Endopodite of first maxilla short and unsegmented.
    c. Exopodites present on all, or all but the last pair of legs; antennular flagella moderately long; no pleurobranchiæ on the last two thoracic somites........*Trachypeneus*.
    cc. Exopodites wanting on all the legs; antennular flagella short; no pleurobranch on the last thoracic somite........*Parapenæus*.
aa. Integument rigid; abdomen more or less carinate throughout its length and marked with furrows; trunk legs without exopodites; pleopods all uniramous........(Subfamily *Sicyoninæ*) *Sicyonia*.

Genus PENEUS Weber.

Peneus Weber, 1795, p. 94.
Penæus Fabricius and most subsequent writers.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Dorsal surface of carapace with a carina extending from the rostrum nearly to the posterior margin and bordered on each side by a deep sulcus........*brasiliensis*.
aa. Dorsal carina about two-thirds as long as carapace and with shorter lateral sulci........*setiferus*.

Peneus brasiliensis Latreille. Shrimp. Pl. xxv, fig. 6.

Penæus brasiliensis Latreille, 1817, p. 156; Stimpson, 1871, p. 132; Coues, 1871, p. 124; Kingsley, 1878–79, p. 330; Rathbun, 1901, p. 100; Sumner, 1911, p. 665.

Integument thin, polished, and translucent. Carapace with a high median carina, continuous in front with the rostrum; extending back almost to the posterior margin of the carapace, and bordered on each side by a deep and broad sulcus; posterior half of carina with a median longitudinal groove; anterior half arcuate, highest above orbit and with nine or ten sharp serrations, the posterior one of which is almost halfway back on the carapace and remote from the others while the anterior six or seven are on the rostrum proper. Lower margin of rostrum with two or three spines, the tip slender, horizontal, and unarmed. Anterior margin of carapace with a strong spine below the base of the eyestalk from which a carina extends backward nearly to the well-marked hepatic spine. Cervical groove extending only halfway from hepatic spine to dorsal carina. A subhorizontal suture below the hepatic spine.

Fourth, fifth, and sixth segments of the abdomen carinate, the sixth having the carina bordered on each side by a sulcus. Telson with a deep median groove and an acuminate tip. Eyes large and prominent, on rather slender stalks. Peduncle of first antenna slightly exceeding tip of rostrum. Second antenna with its scale longer than rostrum, flagellum about one and one-half times as long as body. Legs slender and rather short, the three anterior pairs chelate. Pleopods well developed, all except the first pair provided with two foliaceous branches.

Length of a female, tip of rostrum to tip of telson, 158 mm.; carapace, 52 mm.

In Beaufort Harbor and neighboring localities, especially in the brackish creeks to the north and east of the town this species is abundant. In suitable places great schools of shrimps are found in the summer and fall and are caught for shipment to northern markets. These schools often consist of both *P. brasiliensis* and *P. setiferus*, though the former appears to be the more numerous. Locally shrimps are eaten and are in some demand for use as fish bait. Large individuals are found throughout the summer, but those of immature size appear to be most abundant during the early months of the season. In the fall nearly all are full grown and are to be found in large schools outside the harbor where they are fished for with purse nets. At one haul in 1912 in the bight at Cape Lookout 240 boxes, weighing about 150 pounds each, were taken and shipped from Beaufort to northern markets.

Peneus setiferus (Linnæus). Shrimp. Pl. XXV, fig. 5.

Cancer setiferus Linnæus. 1767, p. 1054.
Penæus fluviatilis Say, 1818, p. 236.
Penæus setiferus Milne-Edwards, 1834–1840, p. 414 [1837], 1837, p. 414; Gibbes, 1850, p. 199; Stimpson, 1871, p. 133; Kingsley, 1878–79, p. 330; Fowler, 1912, p. 316.

In form and general appearance similar to *P. brasiliensis* but with the median carina of the carapace continued backward only about two-thirds the length of the carapace, not grooved posteriorly, with the lateral sulci terminating near the most posterior serration, and provided with nine or ten sharp teeth above, of which the anterior six are on the rostrum proper. Tip of rostrum long and slender, the first spine being about opposite the eye, gently upcurved distally, except the tip which is sometimes depressed; lower surface with two teeth. Spine behind eye, hepatic spine and suture below the latter essentially as in *P. brasiliensis*, cervical groove shorter than in that species.

Abdominal segments as in *P. brasiliensis*.

Peduncle of first antenna considerably and scale of second antenna slightly shorter than rostrum; flagellum of second antenna twice as long as body.

In life the animal is translucent, almost transparent, bluish white with dusky bands and patches composed of minute scattered black specks. The rostrum and sides are tinged with pink. The blades of the pleopods are marked with dark red. The antennæ are dark brown. The uropods have the tips of their blades a very dark brown purple with a narrow stripe of light greenish-yellow along the margin. After death the body whitens and the colors stand out with greater distinctness.

The longer and more slender rostrum, longer antennæ and the shorter sulci lateral to the dorsal carina of the carapace distinguish this species at once from *P. brasiliensis*.

This shrimp appears to attain abundance earlier in the summer than does *P. brasiliensis* and comes to market during the last weeks of July or in early August. Several boat loads were seen late in July, 1912, the first lots consisting of small specimens, the later ones nearly all full grown.

Genus TRACHYPENEUS Alcock.

Trachypeneus Alcock, 1901, p. 15.

Trachypeneus constrictus (Stimpson). Pl. XXV, fig. 9.

Penæus constrictus Stimpson, 1871, p. 135; Kingsley, 1878–79, p. 330.
Parapenæus constrictus Smith, 1885a, p. 174; Rathbun, 1901, p. 101.

Integument smooth and polished, dorsal region of carapace with very fine short, appressed setæ. Carapace carinated on its anterior three-fourths, with a spine behind base of rostrum. Antennal and hepatic spines well developed. Lateral groove extending about three-fifths the length of carapace. Rostrum reaching middle of penultimate segment of first antenna, directed slightly upward, its upper margin usually slightly arched and bearing usually seven (7–9) equidistant teeth diminishing in size toward extremity. Peduncle of first antenna extending beyond eye as far as length of eye; very pubescent above. Abdomen carinate from fourth to sixth segment. Telson with two rounded carinæ above, tapering to a short, acuminate tip, armed on either side with a short spine.

Length of a female, 54 mm.; carapace, including rostrum, 18 mm.; rostrum, 6 mm.

Color in life, translucent white, with purplish gray cloudings and blotches; appendages pinkish.

Specimens occasionally occur within the harbor. On the Blackfish Banks it is more common but is never taken in large numbers.

Genus PARAPENÆUS Smith.

Parapenæus Smith, 1885a, p. 170.

KEY TO THE SPECIES.

a. Dorsal margin of rostrum with less than 12 teeth; eyes of moderate size.................*politus.*
aa. Dorsal margin of rostrum with 12 to 15 teeth; eyes very large..........................*megalops.*

Parapenæus politus Smith. Pl. xxv, fig. 7.

Parapenæus politus Smith, 1881, p. 444; ibid., 1885a, p. 172.

Integument smooth and polished, carapace not setose. Carapace with a low median carina, continuous in front with the rostrum, extending back almost to the posterior margin and bearing a small spine some distance behind base of rostrum. Rostrum arched, distal half deflexed, about as long as eye and falling short of the first article of the antennulary peduncle, dorsal margin with six teeth diminishing in size anteriorly, ventral margin heavily ciliate. Hepatic, antennal and branchiostegal spines well developed, the last placed a little behind the margin of the carapace. A shallow groove extends from behind the eye almost to the posterior margin of the carapace and another, extremely faint, runs upward from the inferior margin at the base of the second pair of legs.

Abdomen two and one-fourth times as long as carapace; fourth, fifth, and sixth segments carinate, the carina ending on each segment in a small tooth. Sixth abdominal segment a little more than twice the length of the fifth. Telson tapering to a sharp point, furrowed above and with a slender spine on each side near the tip.

Two specimens, 50 and 60 mm. long, respectively, were taken by the *Fish Hawk* off Beaufort Inlet in water not exceeding 180 fathoms deep. They differ somewhat, principally in the more strongly curved rostrum, from typical *P. politus* and were at first thought to be specifically distinct, but a careful comparison with the specimens of that species in the United States National Museum shows that these differences are too slight to be worthy of recognition.

Parapenæus megalops Smith. Pl. xxv, fig. 8.

Parapenæus megalops S. I. Smith, 1885a, p. 172; Rathbun, 1901, p. 102.

Covering of abdomen and carapace naked and smooth. Carapace carinate on its anterior half, the carina with a spine behind base of rostrum. Rostrum elevated, arched, terminal half very slender, upper surface armed with 12 to 15 spiniform teeth crowded posteriorly, but becoming more remote and smaller anteriorly; tip reaching to distal end of antennal scales in females; shorter in males. Antennal, hepatic, and branchiostegal spines well developed. No antennal suture. Eyes extremely large, extending laterally beyond carapace. Antennal peduncles extending beyond eyes less than length of eyes; terminal segment longer than penultimate.

Fourth to sixth segments of abdomen with a thin, sharp, median carina. Telson with a lateral as well as two dorsal carinæ.

Length of male, tip of rostrum to tip of telson, 91 mm.; carapace, including rostrum, 24 mm.; rostrum, 9 mm.

A few specimens were dredged by the *Fish Hawk* in deep water off Cape Lookout.

Genus SICYONIA H. Milne-Edwards.

Sicyonia H. Milne-Edwards, 1830, p. 339.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Dorsal carina of carapace with three teeth.
  b. Rostrum with two teeth above and two or three spines at tip.........................*lævigata.*
  bb. Rostrum with three or four teeth above; short; acute at tip.......................*brevirostris.*
aa. Dorsal carina of carapace with two teeth.
  b. Rostrum with three teeth above and one below...................................*dorsalis.*
  bb. Rostrum with two small teeth above...*edwardsii.*

Sicyonia lævigata Stimpson. Pl. xxv, fig. 1.

Sicyonia lævigata Stimpson, 1874, p. 131; Rathbun, 1901, p. 130.

Integument rather firm, very finely granulate and more or less sculptured. Carapace with a median dorsal carina broken into three nearly equidistant, forwardly directed, acute teeth with tufts of setæ between them. Rostrum upturned, its superior margin with two teeth, its tip truncate, with two or three spiniform teeth and reaching nearly to end of antennular peduncle. External maxillipeds considerably longer than antennal peduncle. Third pair of legs exceeding external maxillipeds by length of fingers and half the palm.

Abdomen with a median dorsal carina which terminates on the first segment in an anteriorly directed tooth and on the last segment in a posteriorly directed one; side with shallow sulci, otherwise almost smooth.

Length of a female, 30 mm.

Color, yellowish brown, the cephalothorax darker than the abdomen and sometimes bluish or greenish.

Sicyonia lævigata is fairly common in Beaufort Harbor, especially on shelly bottoms.

Sicyonia brevirostris Stimpson. Pl. xxv, fig. 4.

Sicyonia brevirostris Stimpson, 1874, p. 132.

Integument firm, much sculptured, especially the abdomen; abdomen with scattered tubercles, whole body with a covering of very short and fine setæ. Rostrum short, not equaling eyes, its upper margin with three teeth behind the acute tip. Median carina of carapace with three strong teeth. Antennal and hepatic spines well developed. Peduncle of antennule short, its terminal article a little more than half as long as penultimate. Peduncle of antenna a little shorter than external maxillipeds. Third pair of legs exceeding external maxillipeds by about two-thirds the length of the hand.

Carina of abdomen prominent, fissured, and deeply notched behind on each segment; first segment with an anteriorly projecting tooth, fifth and sixth segments with backwardly directed ones. Anterolateral angles of first, second, third, and fourth segments dentiform, those of the third and fourth developed as stout, outwardly projecting, curved spines; posterior lateral angle of fifth segment spiniform.

Length of a male, tip of rostrum to tip of telson, 78 mm.; carapace, including rostrum, 27 mm.; rostrum, 3.5 mm.

Three specimens, two males and a female, were dredged by the *Fish Hawk* in 17 and 63 fathoms outside the harbor.

Sicyonia dorsalis Kingsley. Pl. xxv, fig. 3.

Sicyonia dorsalis Kingsley, 1878, p. 97; Rathbun, 1901, p. 103.

Integument fairly solid, both carapace and abdomen much sculptured. Carapace with a median dorsal carina with one tooth a little behind the middle and one much smaller near base of rostrum. Rostrum upturned, its superior margin with three teeth, its tip reaching slightly beyond eyes, notched at end and with small tooth on lower surface. External maxillipeds shorter than antennal peduncle. Peduncle of antennule short, the second article twice the length of third. Third pair of legs reaching slightly beyond external maxillipeds.

Abdomen with a high median dorsal carina, the anterior and posterior teeth strong; a minute posterior tooth on fifth segment. Sixth segment with a posterolateral spine above which is a triangular tooth. Full-grown individuals with a posterolateral spine on third, fourth, and fifth segments also.

A single small specimen, 34 mm. long, now in the laboratory collection, was dredged by the *Fish Hawk* a short distance off the inlet in 1902. Dr. Mary J. Rathbun records an example from Porto Rico 90 mm. long.

Sicyonia edwardsii Miers. Pl. xxv, fig. 2.

Palemon carinatus Olivier, 1811, p. 667 (teste Milne-Edwards).
Sicyonia carinata Milne-Edwards, 1837, p. 344; ibid., 1834–1840, t. II, p. 410; Dana, 1852, p. 602; Bate, 1888, p. 294.
Sicyonia edwardsii Miers, 1881, p. 367.

Integument, especially of the abdomen, firm. Carapace nearly smooth and with fine scattered hairs; abdomen deeply sculptured and with scattered tubercles. Dorsal carina of carapace with two teeth. Rostrum directed obliquely upward, its upper margin nearly straight and armed with two small teeth; its tip notched and falling short of eyes. Anterior margin of carapace with a small spine below eye. Lateral spines well developed. External maxillipeds reaching terminal article of antennulary peduncle and exceeding antennary peduncle. Third pair of legs exceeding external maxillipeds by length of fingers.

Abdomen with dorsal carina like that of *S. brevirostris*. Lateral angles of segments not produced into spines.

The right of this species to be included in the Beaufort fauna rests, so far as is known, on a single specimen of 25 mm. long, dredged by the *Fish Hawk* in 141 fathoms off Beaufort Inlet.

Family SERGESTIDAE.

Peneidea having the last two pairs of legs reduced in size or lost and the gills few or wanting.

Three genera are recognized, of which only the following is known from the Beaufort region.

Genus LEUCIFER Milne-Edwards (=LUCIFER of most authors.).

Leucifer Milne-Edwards, 1837, p. 468.

Leucifer faxoni Borradaile. Pl. XXVI, fig. 10.

Lucifer typus. Faxon, 1879, p. 113, pl. 7, figs. 1–3.
Lucifer sp. Brooks, 1883, pp. 57–137.
Lucifer faxoni Borradaile, 1915, p. 228.

Integument smooth, thin, and transparent. Anterior portion of cephalothorax greatly lengthened, bearing the eyes, antennules, and antennæ far in front of the mouthparts and legs; abdomen strongly developed, with large swimmerets and tail fin.

Anterior prolongation of cephalothorax about one and one-half times as long as posterior portion, nearly cylindrical, produced into a small rostrum, a spine on each side behind the eye, and a knoblike suborbital lobe. Posterior portion of cephalothorax with a small spine on each side in front. Eyes large and prominent, on stout conical stalks about one-third the length of the anterior part of the cephalothorax. Peduncle of antennules long and slender; basal article longer than the other two combined; third article shortest; flagella long and slender. Peduncle of antennæ about half as long as first article of the antennular peduncle; flagellum slender, longer than that of the antennule; scale almost linear and fringed along its inner margin with long hairs. Mandibles without a palpus. Two pairs of maxillæ and three pairs of maxillipeds, the last pair pediform, are present. Four pairs of slender legs, the first two pairs short, the last two of nearly equal length and extending forward almost to the end of the cephalothorax. Abdomen much compressed, its segments deepest at the point of insertion of the swimmerets and there produced into a spiniform angle; sixth segment as long as the two which precede it, its posterolateral angles spiniform, a small median spine above the base of the telson and, in the male, two strong lateral spines of which the posterior is curved and about twice as long as the anterior. Telson slender, about half as long as uropods, with a stout spine on each side and a prominent projection on the ventral side near the middle. Uropods about as long as the sixth segment, the outer branch strongly developed, the inner branch much shorter and narrower.

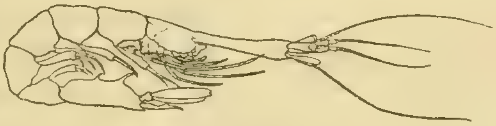

Fig. 4.—*Leucifer faxoni*. ♂. × 10.

Length, 10 to 12 mm.

Color, when alive, almost perfectly transparent; in alcohol, white.

This interesting little shrimp is not uncommon in the waters of the harbor and has been taken in the tow nets throughout the summer. Egg-bearing females were collected June 30, 1912. Outside the harbor it is much more abundant, at times occurring in such great swarms that it constitutes a large proportion of the plankton material.

The development of *Leucifer* was worked out by Dr. W. K. Brooks from material secured, largely, at least, at Beaufort, and his paper, already cited, is a zoological classic. His figures of the animal are the best that have been published and show conclusively that he was dealing with the species that is described above. Unfortunately in this, as in many other cases, Dr. Brooks made no effort to determine the proper specific name of his specimens. Faxon's description and figures show that he also was dealing with the present species to which, with some doubt, he applied the name *Lucifer typus* Milne-Edwards. In a recent paper, however, Borradaile shows that the *Leucifer* of the western Atlantic is not *L. typus* or any other hitherto described species, and proposes for it the name *L. faxoni*.

It was the opinion of Dr. Brooks that *Leucifer* breeds in the marshes which border the harbor along the town front. His reasons for coming to such a conclusion are not altogether satisfactory, and in view of the fact that the shrimp is far more abundant outside than inside the harbor and that the genus is known the world over as a strictly pelagic one, it is very probable that he was mistaken.

Tribe CARIDEA.

Natantia having the third pair of legs not chelate, the pleura of the first abdominal segment overlapped by those of the second segment, the abdomen usually with a sharp bend and the gills always developed as phyllobranchiæ.

This large and important tribe comprises 153 genera, divided among 20 families. Of the latter, 5 are represented in the Beaufort fauna.

Family CRANGONIDAE (=ALPHEIDAE of most authors). The snapping shrimps.

Caridea having the first two pairs of legs chelate, the first pair usually much stronger than the others and often unsymmetrical, the carpus of the second pair of legs subdivided, the eyes small and usually covered by the carapace, the mandibles deeply cleft and the second maxillipeds with a very short seventh article.

Of the 27 recognized genera the following are represented in the Beaufort region:

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Eyestalks covered by the carapace.
  b. Hand of large cheliped cylindrical; trunk legs with exopodites.....................*Synalpheus*.
  bb. Hand of large cheliped compressed; trunk legs without exopodites..................*Crangon*.
aa. Eyestalks completely exposed...*Automate*.

Genus SYNALPHEUS. Bate. Coutière.

Synalpheus Bate, 1888, p. 572; Coutière, 1899, p. 334.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

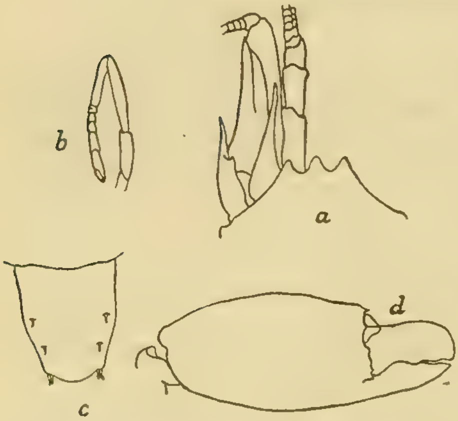

FIG. 5.—*Synalpheus minus*. After Coutière.

a, Front of carapace and appendages; *b*, second leg; *c*, telson; *d*, large chela.

a. Rostrum comparatively broad, not longer than the supra-orbital lobes...................*minus*.
aa. Rostrum comparatively slender, more or less exceeding the supra-orbital lobes.
  b. Movable finger of small cheliped with a conspicuous bunch of curled hairs. Rostrum little longer than supra-orbital lobes...*longicarpus*.
  bb. Movable finger of small cheliped without a bunch of curled hairs. Rostrum considerably longer than supra-orbital lobes...........*townsendi*.

Synalpheus minus (Say). Pl. XXVI, fig. 3.

Alpheus minus Say, 1818, p. 245.
Synalpheus minus Coutière, 1909.

Similar in appearance to the two following species but with a much shorter and broader rostrum which has at the base about the same width as the supra-orbital spines and hardly exceeds them in length. The sides of the telson are not strongly convergent and the spines at its tip are about equal in length. The spine on the basal article of the antennule reaches to near the middle of the second article. The spine on the basal article of the antenna reaches to the end of the first article of the antennule, while the spine of the second article slightly exceeds the third article of the antennule. The smaller cheliped does not bear a brush of hairs. The movable finger of the larger cheliped is heavy, but is not raised into a crest as in *S. townsendi*. The second pair of legs has the carpal articles in the proportion of 5, 1, 1, 1, 2.

Length, 12.5 mm.; carapace, 4 mm.

One specimen which agrees closely with Coutière's description and figures was taken by the *Fish Hawk* on the fishing banks (station 7956) in 16 fathoms.

This is unquestionably the *Alpheus minus* of Say and is almost equally certainly not the *Alpheus minus* of Kingsley, Brooks, Herrick, and others whose papers are commonly listed in the synonomy of the species. These authors, beyond any reasonable doubt, applied the name to the species now known as *Crangon packardi*, which is, as they stated, common in Beaufort Harbor. True *Synalpheus minus*, on the other hand, is not common anywhere in the region, and it is doubtful if it ever occurs in the harbor. It has been recorded by Coutière from farther south and is probably the species recorded by Smith[a] from off Cape Hatteras, in 16 fathoms.

Synalpheus longicarpus (Herrick). Pl. XXVI, fig. 2.

Alpheus saulcyi var. *longicarpus* Herrick, in Brooks and Herrick, 1892, p. 383 (part).
Synalpheus longicarpus Coutière, 1909, p. 53.

Carapace about two-thirds as long as abdomen, subcylindrical, and smooth; crossed by a very faint cervical groove; frontal border produced into a sharp-pointed lobe above each eye; rostrum carinate, slender and slightly longer than supra-orbital lobes.

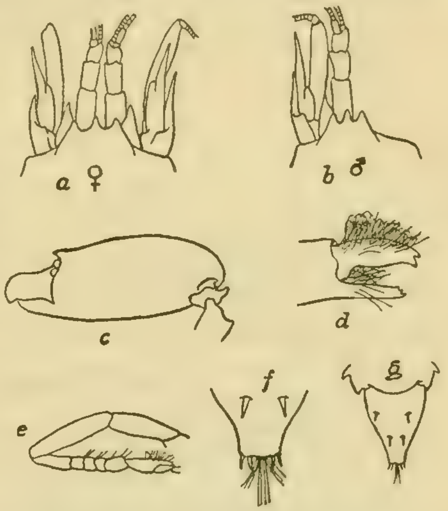

FIG. 6.—*Synalpheus longicarpus*. After Coutière.

a, Front of carapace and appendages of female; *b*, same of male; *c*, large chela; *d*, fingers of small cheliped; *e*, one of the second pair of legs; *f*, distal end of telson; *g*, telson.

Abdomen smooth, tapering; telson with strongly convergent, sinuous sides and truncate tip which bears four slender spines, upper surface with four strong movable spines; sixth segment and basal article of uropod with flat marginal spines.

Eyes small. Basal article of antennule with a spine on outer margin which does not reach to the end of the article. Basal and second articles of antenna each with a strong, acute, forwardly directed spine, of which the tip of the one on the second article exceeds the other and extends a little beyond the base of the third article of the antennule. Chelipeds very unequal, the smaller one with a conspicuous brush of curled hairs on the movable finger; the larger one cylindrical, with short fingers of which the movable one is much the larger and strongly curved. Second pair of legs with the carpus subdivided into five articles which have approximately the proportions of 4, 1, 1, 1, 2.

Length, 22 mm.; carapace, 9.5 mm.

Color, a translucent milky white; the tip of the large chela brown.

Many specimens of this snapping shrimp have been collected from the interior of sponges thrown upon the shore by the waves. On the fishing banks it is probably the commonest member of the genus, often occurring in enormous numbers in the large sponges which are to be obtained in that locality. In August, 1915, such a sponge about 2 feet in height, belonging to the genus *Spirastrella*, was brought in by the *Fish Hawk*. When cut open its larger canals were found to be full of *S. longicarpus*, several hundred of which were saved before the patience of the collector was exhausted. A considerable number of these shrimps were found to be infested with isopod parasites, one a species of *Phryxus* being attached to the lower surface of the abdomen, while the other, a species of a new genus, *Synsynella*,[b] was an inhabitant of the branchial chamber.

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[a] Smith, Sidney I.: Report Commissioner of Fisheries for 1885, p. 54.

[b] *Phryxus subcaudalis* Hay and *Synsynella deformans* Hay, Proc. U. S. Nat. Mus., 41, pp. 569–572, 1916.

Synalpheus townsendi Coutière. Pl. XXVI, fig. 1.

Synalpheus townsendi Coutière, 1909, p. 32.

Similar in form to *S. longicarpus* but with a much slenderer rostrum which considerably exceeds the supra-orbital lobes and reaches slightly beyond the distal end of the basal article of the antennule. The sides of the telson are not as strongly convergent and are slightly produced into little angles at the distal end and the inner pair of spines are slender and about three times as long as the outer one on each side. The spine on the basal article of the antennule reaches beyond the end of the article and slightly exceeds the rostrum. The spine of the basal article of the antenna extends to about the middle of the spine of the second article, while the latter slightly exceeds the distal end of the third article of the antennule. The smaller cheliped lacks the brush of curled hairs on the movable finger and the larger one has the upper margin of the movable finger elevated into a thick crest. Second pair of legs with the carpus divided into five articles which have the approximate proportions of 5, 1.5, 1, 1, 2.

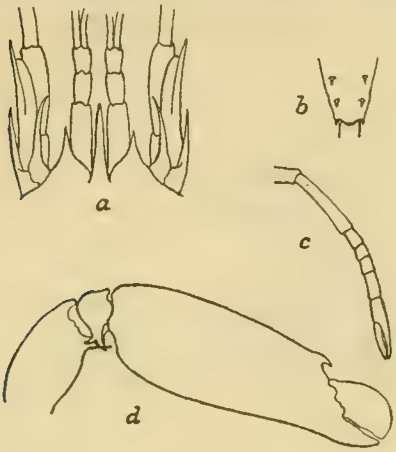

FIG. 7.—*Synalpheus townsendi.*
a, Front of carapace and appendages; *b*, telson; *c*, second leg; *d*, large cheliped.

Length of a female, 16 mm.; carapace, 7 mm.

Color in life, body and legs a light pellucid pinkish red, the large chela, pink changing to green on the fingers.

Five specimens of a little snapping shrimp which have been identified as this species were taken at the fishing banks (station 7943) in 13½ fathoms of water. Another series was taken at the same locality (station 8293) from the interior of a large sponge dredged in 16 fathoms. They do not agree in all respects with Coutière's description and figures, but appear to stand about halfway between his variety *brevispinis* and the typical form. The species has been previously reported from the coast of North Carolina and its presence on the fishing banks is not surprising.

Genus CRANGON (=ALPHEUS of most authors).

Crangon Weber, 1795, p. 94.
Alpheus Fabricius, 1798, p. 380; Coutière, 1899, p. 336.

KEY TO THE SPECIES OF THE BEAUFORT REGION.[a]

a. Orbital lobes of carapace with a small spine in front. *formosus.*
aa. Orbital lobes of carapace without a distinct spine.
  b. Orbital lobes forming a toothlike projection; large hand with a groove above and below along outer margin and between these grooves a tooth. . . . . *packardii.*
  bb. Orbital lobes rounded; hand broad and notched on both margins.
    c. Base of rostrum passing gradually into the lateral dorsal surface. . . . . *heterochælis.*
    cc. Base of rostrum with its borders sharply defined. . . . . *armillatus.*

Crangon formosus (Gibbes). Pl. XXVI, fig. 5.

Alpheus formosus Gibbes, 1850, p. 196; Rathbun, 1901, p. 106.
Alpheus poeyi Guèrin Meneville, 1857, p. 10.

Carapace one-half as long as the abdomen, compressed, not grooved; rostrum beginning at posterior line of the eyes and reaching, or nearly reaching, the second article of the antennule, flat above, its margins concave at base but nearly parallel anteriorly and with scattered stiff hairs; the tip rounded, with two or three minute spines; orbital lobes with an acute, anteriorly directed spine much shorter than the rostrum.

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[a] In the account of his trip to Beaufort, Stimpson (Amer. Jour. Sci. & Arts, ser. 2, vol. XXIX, p. 442–445, 1860) mentions *Alpheus intermedius* as a member of the Beaufort fauna. It has been impossible to ascertain what species he had in mind and a thorough review of the literature has failed to bring to light any crustacean described under that name.

Antennules with the inner branch filiform; outer branch thick, but bearing near its tip a filiform extension; basal spine slightly exceeding the first article. Antennular scale slightly longer than the peduncle, basal spine shorter than basal spine of antennule. Chelæ very unequal; the larger one compressed (but not nearly so much as in *C. heterochælis*) smooth above and unnotched along the margins; movable finger about one-fourth as long as hand; smaller chela much slenderer, its inner surface with a stout spine overhanging the base of the movable finger; the latter about half as long as hand. Carpal articles of second pair of legs having the proportion 4, 1.7, 1, 1, 2.

Length of an ovigerous female, 31 mm.; carapace, 11 mm.

Color: Along the median line, extending from the distal end of the peduncles of the antennules to the base of the telson a narrow light stripe, light orange-yellow anteriorly merging into yellowish green and finally gray posteriorly; on each side of this a broad stripe of chocolate brown; below this, along each side, a stripe of white; and below this a stripe of light vinaceous brown followed on the abdomen by a border of ultramarine blue. The chelæ are greenish brown with orange-red fingers. The antennules, antennæ, and walking legs are ultramarine blue. The telson and tail fins are blotched and bordered with yellow.

Two specimens, one a female with eggs almost ready to hatch, of this strikingly colored snapping shrimp were taken by the *Fish Hawk* on the fishing grounds at a depth of about 15 fathoms. The species was described by Gibbes from Key West, Fla., and since that time it has not been reported on the coast of the United States. It has, however, been collected in Porto Rico, Cuba, Bermudas, and Brazil.

Crangon packardii (Kingsley). Pl. XXVI, fig. 4.

Alpheus packardii Kingsley, 1879 (1880), p. 417; Rathbun, 1901, p. 107.
Alpheus bermudensis Bate, 1888, p. 547.
Alpheus minus Herrick, in Brooks and Herrick, 1892, p. 372.

Carapace about two-thirds as long as abdomen, somewhat compressed, cervical groove hardly evident; front produced into an obtuse angle above each eye; rostrum carinate, the carina extending back as far as base of eyestalks, the spiniform tip reaching second article of antennule.

Abdomen compressed, smooth, tapering. Telson rather small, faintly grooved; upper surface with four strong, movable spines; tip fringed with small spines.

Eyes well developed but completely covered by the carapace. Antennules with the inner branch slender, the outer one shorter and with its proximal four-fifths enlarged. Antennæ a little longer than body, slender; scale as long as peduncle of antennule and with a strong apical spine; basal segment with a strong spine on lower part of outer surface. Third maxillipeds slender, not reaching tip of antennal scale, terminal segment with long hairs. Chelæ unequal, the larger one broad and flattened, slightly sinuate along inner margin; outer margin with a longitudinal groove above and below, the ridge between them ending in a strong tooth behind base of dactylus; dactylus heavy, curved, toothed at base; both fingers with setæ at tips. Smaller hand about one-half as wide and three-fourths as long as the larger one, similarly formed but with a sharp spine above at base of dactylus; no basal tooth on dactylus and both fingers slenderer and more hairy. Carpus much reduced. Meros with a spiniform tooth near distal end and one or two small spines below. All the legs with scattering long hairs especially at the joints. Carpal articles of second pair of legs diminishing as follows: Second, first, fifth, third, and fourth.

Length of a male, 27 mm.

Color, gray.

This, the commonest snapping shrimp of the region, is usually found on shelly bottoms and is frequently brought up in the dredge. It may also be found on wharf piles and among old oyster shells. Its snap, although readily enough noticed, is weak in comparison with that of its larger relative *C. heterochælis*.

This is, in all probability, the species indicated by the name *Alpheus minor*, in the older lists of the crustaceans of the Beaufort region. As determined by Coutière, *Alpheus minor* Say is a *Synalpheus;* it is apparently one of the rarest crustaceans of the region and was probably never recognized nor collected here until within a year or two. That the *Alpheus minus* (or *minor*) of Herrick, Brooks, and other students of the Johns Hopkins summer laboratory was *Crangon packardii* is conclusively proved by the colored figure in Herrick's paper.

Crangon heterochælis (Say). Pl. XXVI, fig. 6.

Alpheus heterochælis Say, 1818, p. 243; Milne-Edwards, 1837, t. II, p. 356; Kingsley, 1878–79, p. 329; Herrick, in Brooks and Herrick, 1892, p. 372; Rathbun, 1901, p. 107; Coutière, 1910, p. 485.

Carapace slightly more than half as long as abdomen, slightly compressed and without grooves; front produced into a rounded lobe above each eye; rostrum carinate, the carina not extending back as far as base of eyestalks and the tip falling short of second article of antennule; rostro-orbital depressions passing gradually into dorsal surface. Abdomen compressed, smooth, tapering; telson with subparallel sides and rounded tip; the four movable spines of the upper surface and those of the distal border relatively much weaker than in *C. packardii.*

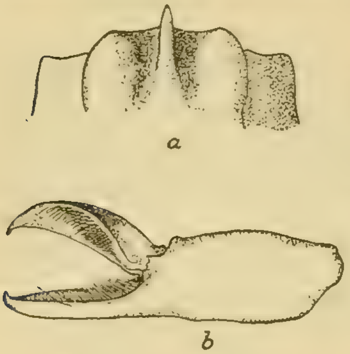

FIG. 8.—*Crangon heterochælis.*

a, Front of carapace; *b*, small chela.

Eyes relatively small, covered by the carapace. Antennules with inner branch filiform, about half as long as antenna; outer branch with proximal half expanded. Antennæ a little longer than body, very slender; scale with a strong apical spine which slightly exceeds the antennular peduncle; basal segment with a rather weak spine below. Chelæ very unequal; the larger one much distorted, the upper and lower surfaces with irregular shallow grooves and the outer and inner margins deeply notched near base of fingers; dactylus very broad and heavy, strongly curved and with a very large basal tooth. Smaller chela, in the male, with the dactylus peculiarly flattened and expanded on its outer surface; fingers of small chela, in both sexes, much weaker, less curved, and more hairy than in the large chela. Carpal articles of second pair of legs diminish as follows: First, second, fifth, third, fourth.

Length of a male, 40 mm.; carapace, 13 mm.; a female, 50 mm.

Color, dark, translucent sea green, slightly flushed with purple on sides of carapace; with white markings on chelipeds; walking legs pale vermilion; tips of uropods blue, with a narrow border of orange on distal margin, the outer blade having in addition a patch of vermilion just above the blue, and a narrow white border; articular surfaces and points of abdominal segments and a small streak along cervical groove white.

This species of snapping shrimp, while not as common in the Beaufort region as *C. packardii*, is far from rare and is locally often quite abundant. Its favorite habitat is around the edges of oyster reefs where it digs large burrows in the mud or conceals itself among the shells. When captured the loud snapping sound it makes, which is comparable to the cracking of a small whip, is sure to command attention. Females bearing their large masses of clear apple-green eggs have been taken early in July. An isopod parasite (*Probopyrus alphei* Richardson) is occasionally found in the gill chamber of this snapping shrimp.

Crangon armillatus (H. Milne-Edwards). Pl. XXVII, fig. 1.

Alpheus armillatus H. Milne-Edwards, 1834–1840, t. II, p. 354; Coutière, 1910, p. 485.

Very closely resembling *C. heterochælis* except in the rostrum and the small chela of the male.

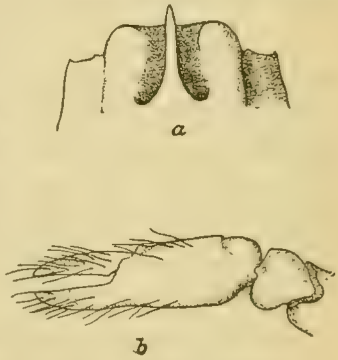

FIG. 9.—*Crangon armillatus.*

a, Front of carapace; *b*, small chela.

The rostrum has the form of a narrow crest which, just behind the eyes, widens abruptly into a triangular area the borders of which are slightly concave and very distinctly limit the rostro-orbital depressions, even slightly overhanging them in adult specimens.

The dactylus of the small chela of the male lacks the setose crests and expanded external surface so characteristic of *C. heterochælis.*

By Coutière this species is said to be abundant and widely distributed along the Atlantic coast and often to accompany *C. heterochælis*. At Beaufort, however, it does not appear to be common, a single specimen, dredged by the *Fish Hawk*, being for a long time the only one in the laboratory collection, but after the severe storm of September 4, 1913, another individual was found in a small boat that had been sunk off Pivers Islands. On August 20, 1914, 6 specimens, 3 males and 3 females, were collected under the rocks of the jetty east of Fort Macon. A male and female were found together in every case in a hollow under a flat rock. The males were colored much like *C. heterochœlis*, except that the conspicuous orange and vermilion areas on the tail fin were lacking. The females were a deep greenish blue with white marking on the large chela. During the night of August 20 a large male shed his shell but increased very little, if any, in length. To provide for the withdrawal of the large hand through the relatively very slender wrist a large oval area on the upper and inner surface of the proximal part of the shell of the hand is detached and the carpus, meros, and ischium, at least, are split lengthwise so that the hand is not drawn through them at all.

Genus AUTOMATE De Man.

Automate De Man, 1897, p. 529.

Automate kingsleyi Hay. Pl. XXVI, fig. 7.

Automate kingsleyi Hay, 1917, p. 72.

Cephalothorax about half as long as abdomen, subcylindrical, with a large sinus in front behind the eyestalks in which the rostrum appears as a small median projection. Eyestalks contiguous, broad at the base, corneal surface well developed and, in lateral view, with a minute point on the anterior surface. Antennular and antennal peduncles very long, the former with a short scale which barely exceeds the basal article, and the latter with a long narrow scale which extends to the middle of the terminal article. Third maxillipeds exceeding antennal peduncles by less than the length of their terminal article. Chelipeds unequal and somewhat dissimilar, the larger one appearing to be stouter and rougher than its mate; fingers slightly gaping, the thumb in line with the hand and broad at base; movable finger much narrower and rather strongly curved; carpus short; meros about as long as movable finger. Second pair of legs about as long as chelipeds but very slender, weakly chelate and with the carpus divided into five articles having the proportions of $1, 1\frac{1}{4}, \frac{4}{5}, \frac{2}{3}, \frac{4}{5}$.

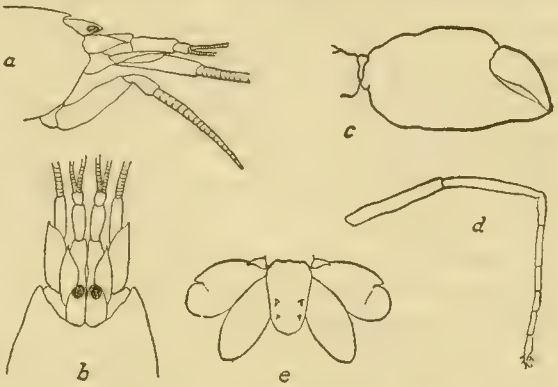

FIG. 10.—*Automate kingsleyi*, type, ♀ ×4.

a, Front of carapace and appendages, lateral view; *b*, the same, dorsal view; *c*, large hand; *d*, second leg; *e*, telson and uropods.

Abdomen well developed, compressed, with strong swimmerets. Telson tapering, armed above at each side with two spines, one of which is at about the middle of the length and the other at about halfway between the middle and the distal end; terminal spines well developed. Uropods with oval blades.

Length of a female (type) 16 mm.; cephalothorax 4 mm.

Color, in life almost transparent except for a small amount of red pigment on the appendages and telson.

A single specimen, a female carrying orange-yellow eggs, was collected on Shark Shoal breakwater July 9, 1916, by Mr. O. W. Hyman. It was kept alive in the laboratory for over a month, during which time the eggs dropped off without hatching and the animal moulted twice without appreciably increasing in size.

The species appears to be very close to *A. evermanni* Rathbun but differs in the length of the third maxillipeds, the proportions of the articles of the carpus of the second pair of legs, the arrangement of the spines of the dorsolateral surface of the telson, the width of the caudal laminæ and the slightly more developed rostrum. It also bears a good deal of resemblance to *A. acanthopus* De Man, but it differs from it in having the scale of the second antenna longer than the basal article, the more extensive corneal surface of the eyes and the outline of the front margin of the carapace. From both these species and from all the other species of the genus, it differs in the shape of the hands. The specimen is a female, but the large hand is as broad and heavy and the palm is as short as the hand of the male of any other member of the genus.

The species has been named in honor of Dr. J. S. Kingsley, to whose interest and industry much of our knowledge of the Beaufort crustaceans is due.

Family OGYRIDAE nov.

Caridea having the first two pairs of legs chelate but of nearly equal size and not much, if any, larger than the other legs, the carpus of the second legs subdivided, the rostrum small or wanting, the eyestalks long, slender, and fully exposed but with the retinal surface reduced, the telson thick and obtusely pointed, the blades of the uropods curved outward, a thelycum present in the female.

The family thus characterized is coterminous with the genus *Ogyris* and, probably, should stand between the Crangonidæ and Hippolytidæ. Coutière, holding that *Ogyris*, *Automate*, and *Pterocaris* are closely related and that *Automate* is unquestionably akin to *Crangon*, places *Ogyris* in the family Alpheidæ (=Crangonidæ). It is evident, however, that Coutière had based his conclusions on the descriptions and figures of other writers without having had an opportunity to examine specimens of either *Ogyris* or *Pterocaris* and perhaps *Automate* also. Ortman, who had seen specimens of *Ogyris*, placed the genus in the family Hippolytidæ. None of these observers appears to have noticed the presence of a thelycum in the female. Having before us representatives of *Ogyris* and *Automate*, as well as several typical genera of both the families mentioned, we have come to the conclusion that *Ogyris* differs too greatly and in too many characters to admit of our placing it in either family. Its resemblance to *Automate* is very slight, and it appears also to be very different from *Pterocaris*.

Genus OGYRIS Stimpson.

Ogyris Stimpson, 1860, p. 36.

Ogyris alphærostris Kingsley. Pl. XXVI, fig. 9.

Ogyris alphærostris Kingsley, 1880, p. 420.

Cephalothorax about half as long as abdomen, the carapace thin, polished, sparingly pubescent, lightly grooved and with a rather strong, movable spine on the median line a little behind the very small rostrum. Eyestalks about half as long as carapace, rather broad at base, becoming almost thread-like distally but with the tip enlarged. Basal article of antennule with a strong external and a smaller superior spine, the entire peduncle about four-fifths as long as eyestalk; flagella of equal length. Antennal peduncle shorter than that of the antennule; flagellum slender and about twice as long as carapace; scale lanceolate, extending to the distal end of second article of antennular peduncle. Third maxillipeds pediform, stronger and longer than any of the legs, their tips considerably exceeding the eyes. Legs all slender, alike on the two sides, the first and second pairs chelate, the second pair the longer and with its carpus subdivided into four articles which have the proportions of 7½, 2½, 1, 2. Third and fourth legs normal, fifth legs much

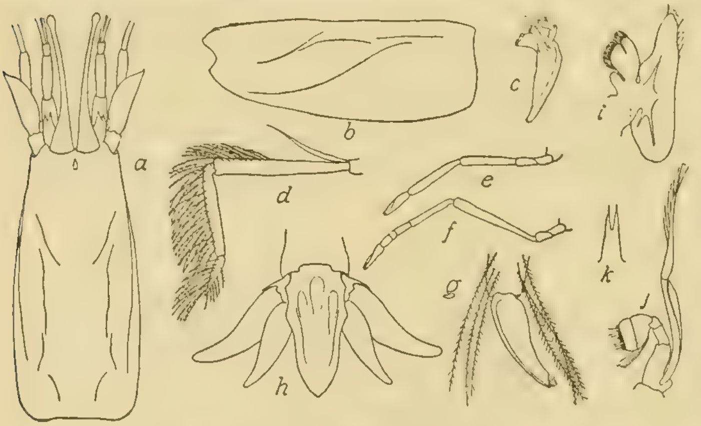

FIG. 11.—*Ogyris alphærostris*, ♀ ×4½.

a, Cephalothorax, dorsal view; *b*, carapace, lateral view; *c*, mandible; *d*, third maxilliped; *e*, first leg; *f*, second leg; *g*, tip of fourth leg, ×40; *h*, telson and uropods; *i*, first maxilliped; *j*, second maxilliped; *k*, thelycum.

more slender. Thelycum consisting of an anterior thin plate bifurcate anteriorly and a posterior shorter emarginate plate which are situated on the sternum between the last three pairs of legs. Telson about as long as sixth abdominal segment, thickened and convex above, its margins sinuate and converging to a narrow, rounded tip. Both blades of uropods with their distal third curved outward. Plumose hairs, mostly long and slender, are present in abundance along the front of the carapace, the margins of the telson and uropods and the superior surface of most of the legs.

Length, 27 mm.; carapace, 8.5 mm.; antenna, 16 mm.

Color, a translucent white, flushed with pink and yellow on the tail fin and legs.

A single specimen of this shrimp, an egg-laden female, was taken in the otter trawl in about 2 fathoms of water off the ocean beach of Bogue Bank about a mile west of Fort Macon on July 30, 1914. It was taken to the laboratory and kept alive for several days in a small aquarium where its behavior, as well as its appearance, strongly suggested some *thalassinid*.

The specimen is of unusual interest as it is the second one of the species and genus to be recorded from the Atlantic coast of the United States, and it throws a good deal of light on a very inadequately known group of crustaceans. There can be no reasonable doubt that it is correctly identified as *O. alphærostris* since it agrees in all essential respects with Kingsley's description of that species, and the locality at which it was collected is reasonably near the type locality. Kingsley's specimen was collected by Prof. Webster on the ocean side of Northampton County, Va., and is now in the collection of the United States National Museum. Unfortunately, however, it and several other specimens which would be of value in the present connection have been sent to Dr. H. Coutière, of the Paris Museum, for study and no direct comparison can be made. Kingsley stated that it was in bad condition, and this fact may account for some of the discrepancies between his description and figure and the specimen in hand.

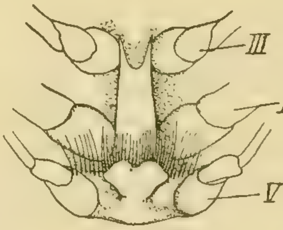

FIG. 12.—*Ogyris alphærostris.* Sterna of last three thoracic segments showing the thelycum. ×7.

At the present time four species of *Ogyris* are known: *O. orientalis* Stimpson[a] from the China Sea and southern Japan, *O. alphærostris* Kingsley from the coasts of Virginia and North Carolina, *O. occidentalis* Ortmann[b] from the mouth of the Tocantins River and from southwestern Louisiana, and *O. sibogæ* De Man[c] from the Sulu Sea and Saleh Bay in the Dutch East Indies.

It has been assumed that the triarticulate carpus of the second pair of legs of *O. orientalis* and *O. alphærostris* distinguishes them at once from *O. occidentalis* and *O. sibogæ* in which this part is described as being quadriarticulate. There is little doubt, however, that in the use of the term *triarticulate* both Stimpson and Kingsley referred to the articulations while Ortmann and De Man referred to the articles of the carpus, and that an examination of the specimens will show that throughout the genus the carpus is composed of four articles. It will also probably be found that in all four species there is a small rostrum and that the telson is thick, uneven above, and with sinuous sides. Assuming these characters to be present, *O. alphærostris* is distinguished from the others by its smooth, noncarinate carapace, *O. occidentalis* may be known by the presence of seven to nine teeth, and *O. orientalis* and *O. sibogæ* by the presence of four or five teeth on the dorsal carina of the carapace. The last two species may, perhaps, be distinguished from each other by the larger size of the rostrum and the more strongly developed protuberance on the lateral margin of the telson in *O. sibogæ*, but one is inclined to believe that they may prove to be identical.

Whether a thelycum is present in the female of any other species of *Ogyris* than the one here described can not be ascertained. Such a structure is not mentioned in any other description, but that fact does not prove its absence. The specimens previously described have been, in nearly every instance, very small or more or less mutilated and under such conditions the thelycum might easily have been overlooked or mistaken for something else. A thelycum is found in the shrimps of the family Peneidæ and a somewhat similar sperm receptacle is characteristic of the crawfishes of the family Astacidæ, but its occurrence and unusual development in *Ogyris alphærostris* is most unexpected.

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[a] Proc. Acad. Nat. Sci. Phil. XII, 36, 1860.

[b] Ergibnisse der Plankton-Exped. der Humboldt-Stiftung. Dekapoden and Schizopoden, 1893.

[c] Siboga Expedition, Decapoda, monograph XXXIXa.

Family HIPPOLYTIDAE.

Caridea having the first two pairs of legs chelate but the first pair not much stronger than the rest, the carpus of the second pair of legs subdivided, the eyes well developed and not covered by the carapace, the mandibles usually deeply cleft, and the second maxillipeds with a very short seventh article.

Of the 27 genera now recognized, the following are represented in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Carpus of second pair of legs vary from two to five articles.
  b. Rostrum exceeding the eyestalks.
    c. Front margin of carapace with not more than one spine below the eye.
      d. Rostrum with teeth above and below.......................................*Hippolyte.*
      dd. Rostrum finely serrate above, coarsely serrate below..........................*Tozeuma.*
    cc. Front margin of carapace with several small spines below the eye; rostrum toothed at the tiponly..*Latreutes.*
  bb. Rostrum not exceeding the eyestalks..*Concordia.*
aa. Carpus of second pair of legs composed of many articles..........................*Hippolysmata.*

Genus HIPPOLYTE Leach.

Hippolyte Leach, 1814, p. 431.

Hippolyte pleuracantha (Stimpson). Pl. XXVI, fig. 8.

Virbius pleuracanthus Stimpson, 1874, p. 127; Kingsley, 1878–79, p. 329; Fowler, 1912, p. 330, pl. 95.

Carapace thin and smooth, anterior border with a spine below eye, side with a sharp hepatic spine behind base of antenna and a small spine on each side at base of rostrum. Rostrum rather stout at base, thin distally, slightly decurved, armed above with two or three teeth, below with one tooth near the tip and two farther back; tip reaching to extremity of antennular peduncle. Outer flagellum of antennule thickened, about as long as antennal scale, and about four-fifths as long as inner flagellum. Antennal scale large, extending about one-third its length beyond tip of rostrum. First pair of legs small, chelate. Second pair of legs chelate, the carpus triarticulate. Dactyli of other legs broad, compressed, and armed along their inner edge with small spines. Abdomen strongly geniculated between the third and fourth segments. Posterior part of third segment raised and produced into a sort of hood which overhangs the fourth segment. Telson smooth above, margins with two small, movable spines on each side; tip truncate and armed with slender spines. Dorsal surface of abdomen and thorax, tips of abdominal pleuræ, and distal portion of eyestalks with tufts of plumose hairs.

Length of adult females, 12 to 18 mm.

Color, often a bright green but usually mottled brown or red.

This little shrimp, like *Tozeuma carolinense*, is to be found in abundance on the submerged *Zostera* in various parts of the harbor. It may also be found in considerable numbers about the rock jetties off Fort Macon. Egg-bearing females occur throughout the summer.

Genus LATREUTES Stimpson.

Latreutes Stimpson, 1860, p. 27 (96).

Latreutes ensiferus (H. Milne-Edwards). Pl. XXVI, fig. 13.

Hippolyte ensiferus H. Milne-Edwards, 1834–1840, t. II, p. 374.
Latreutes ensiferus Stimpson, 1860, p. 27 (96); Bate, 1888, p. 583; Rathbun, 1901, pt. 2, p. 114; Sumner, 1911, pt. 2, p. 664.

Integument smooth and polished, body slender and but slightly humped at end of third abdominal somite. Carapace subcylindrical, with a small dorsal spine; a strong postocular spine and a series of five to eight small spines along anterior margin below eye. Rostrum nearly as long as carapace, rather stout at base but rapidly tapering to a thin, deep, slightly upcurved blade smooth above and below and serrate at the apex. Antennæ very slender, longer than the body; scale almost as long as rostrum, tapering to a narrow point. First pair of legs short and stout; hand inflated, with short fingers and articulated at lower angle with carpus; carpus with its anterior margin excavate to receive the hand, its superior angle with a bundle of hairs. Second pair of legs slender, the carpus divided into three articles of which the central is the longest. Third, fourth, and fifth legs slender, with long spines on inferior margin of propodi; dactyls bifurcate at tip.

Telson narrow, tapering, upper surface with two pairs of small spines near margin, tip obtuse and armed with a strong median spine on either side of which are two slender spines.

Length of a male, 12 mm.; carapace, including rostrum, 5 mm.; rostrum, 2.5 mm.

In life it is almost transparent and colorless. It lives among floating *Sargassum* and at times is easily taken in the harbor and along the sea beaches. An occasional individual is found to carry an isopod parasite (*Probopyrus latreuticola* Gissler)) in one of its branchial chambers.

Genus TOZEUMA Stimpson.

Tozeuma Stimpson, 1860, p. 26 (95).

Tozeuma carolinense Kingsley. Pl. XXVII, fig. 2.

Tozeuma carolinensis Kingsley, 1878a, p. 90; ibid., 1880a, p. 413; Rathbun (*T. carolinense*), 1901, p. 114.

Elongate, compressed. Carapace smooth and polished, its anterolateral angle with a spine, a triangular tooth below eye, and a strong spine on either side at base of rostrum. Rostrum slender, almost twice as long as remainder of carapace, rounded and almost unarmed above, base somewhat flattended and horizontal, distally inclined slightly upward, serrated below and lamellate toward base. Outer flagellum of antennule thick and much shorter than inner, neither quite reaching tip of antennal scale. Antennæ longer than rostrum; scale lanceolate, less than half as long as rostrum. Legs all short; first pair very short, stout, hand inflated, fingers curved, closing completely; second pair also chelate, very slender. Carpus triarticulate; other legs with simple, curved dactyli.

Abdomen strongly geniculated between third and fourth segments, the third segment of the male bearing a low hump; fifth segment with a spine on each side on posterior margin; sixth segment with a posterolateral spine and a stronger one on each side at base of telson; telson with two pairs of dorsal spinules, posterior margin armed on each side with one long and one short spinule.

Length of a male, 40 mm.; carapace, including rostrum, 19 mm.; rostrum, 12 mm.

Color usually green but sometimes gray or grayish red.

Very common in nearly all parts of the harbor where there is a growth of *Zostera*.

Genus CONCORDIA Kingsley.

Concordia Kingsley, 1880, p. 415.

Concordia gibberosus Kingsley. Pl. XXVI, fig. 11.

Concordia gibberosus Kingsley, 1880a, p. 415.

Carapace, rather short, elevated and armed dorsally with five or six slender spines the first of which is near the extremity of the rostrum while the last is a little forward of the middle of the carapace, these teeth well separated and the carapace between them not carinate; rostrum short, little if any advanced beyond the eyes. Abdomen strongly bent in the middle; telson narrow, sides straight, tapering to an acute tip. Eyestalks short and stout. Antennules with the basal articles ciliate above, flagella short, the outer one stout and ciliate, the inner one slender. Antennal scale extending to about the middle of the flagella of the antennule; flagellum of antenna slender and about twice as long as the carapace. First pereiopods short, stout, fingers shorter than the palm; second pereiopods longer and slenderer, carpus composed of three articles of which the distal and proximal ones are of nearly equal length and considerably shorter than the intermediate one. The other pereiopods are slender, the propodal articles with a few minute spines on the posterior border, the dactyls short, curved and with spines on the concave margin.

Length, 8 to 12 mm.

This species has not been detected within recent years. The original specimen, collected at Fort Macon, by Prof. H. E. Webster and described by Kingsley, is preserved in the United States National Museum. Other specimens are from "off South Carolina," and Punta Rassa, Fla. The type specimen lacks some of the pereiopods, but the others show that the carpus consists of three articles instead of two, as has been understood from Kingsley's description.

Genus HIPPOLYSMATA Stimpson.

Hippolysmata Stimpson, 1860, p. 26 [95].

Hippolysmata wurdemanni (Gibbes). Pl. XXVI, fig. 12.

Hippolyte wurdemanni Gibbes, 1850, p. 197.
Hippolysmata wurdemanni Kingsley, 1878a, p. 90; ibid, 1880a, p. 411.

Carapace dorsally carinate on anterior half and with a spine about midway between tip of rostrum and posterior margin. Rostrum reaching distal end of second article of peduncle of antennule, slightly decurved, armed above with four teeth and below with three or four teeth. Anterior margin with a strong spine behind base of antenna. Antennules with the inner flagellum slender, about as long as body; outer flagellum with about 20 basal segments thickened and bearing at about the seventeenth segment a long slender flagellum similar to the inner one. Antennal scale long, narrow, truncate at tip and with a strong apical spine; flagellum considerably longer than body. First pair of legs with carpus and hand of nearly equal length, fingers half as long as palm. Carpus of second pair about forty-seven articulate, sharply bent at about the nineteenth articulation.

Abdomen smooth, not strongly geniculate. Telson narrow, straight sided, upper surface with four small, movable spines forming a square near middle; tip truncate, with two slender spines.

Length of a female, 30 mm.; carapace and rostrum, 11 mm.; rostrum, 3 mm.

Color, a translucent white with beautiful longitudinal and transverse markings of red.

Commonly found at Beaufort swimming near the stone jetties or among hydroids growing on piles.

Family PALAEMONIDAE.

Caridea having the first two pairs of legs chelate, the second pair usually larger than the first, the carpus of the second pair of legs not subdived, the rostrum long, compressed, armed with teeth and not movable, the mandibles deeply cleft and the second maxillipeds with a very short seventh article.

Twenty-six genera are now recognized of which four are represented in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Legs of the second pair approximately alike in size and shape
  b. Rostrum with teeth both above and below.
    c. Mandibles with a palp..*Palæmon*.
    cc. Mandibles without a palp..*Palæmonetes*.
  bb. Lower surface of rostrum toothless except at tip...............................*Urocaris*.
aa. Legs of second pair dissimilar, one of them greatly enlarged........................*Coralliocaris*.

Genus PALÆMON Fabricus.

Palæmon Fabricus, 1798, p. 387; *Leander* Desmarest, 1849, p. 87; Stimpson, 1860, p. 40 [109].

Palæmon tenuicornis Say. Pl. XXVII, fig. 6.

Palæmon tenuicornis Say, 1818, p. 249; Sumner, 1911, p. 663.
Palæmon tenuirostris H. Milne-Edwards, 1834-1840, t. II, p. 395.

Form stout, integument firm, translucent. Cephalothorax short. Carapace almost as deep as long, its front margin with a spine just below the eye and another a little back at the base of the antenna. Rostrum with its axis decurved but upper margin of crest almost straight, armed above with 11 or 12 teeth and below with 6 or 7, the teeth more and more crowded distally and the spaces between them densely ciliated.

Peduncle of antennules shorter than rostrum; outer flagellum very slender and much shorter than the inner one which has its basal portions thickened and bears a long, slender side branch near its base. Antennal scale reaching to tip of rostrum, tapering very slightly to a truncate tip, apical spine small; flagellum very slender, about as long as body. First pair of legs weak, carpus shorter than hand, palm shorter than fingers.

Abdomen bent and slightly humped at end of third segment. Upper surface of telson slightly grooved and with four small spines.

Length of a female, 45 mm.; carapace, including rostrum, 16 mm.; rostrum, 9 mm.

This shrimp has been collected from floating *Sargassum* in the harbor, from the piles of the town wharves, and outside the harbor, by the *Fish Hawk.*

Genus PALÆMONETES Heller.

Palæmonetes Heller, 1869, p. 157.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Second pair of legs long, considerably exceeding the rostrum.
  b. Fifth pair of legs not reaching the tip of the rostrum; marine.............................*carolinus.*
  bb. Fifth pair of legs exceeding the tip of the rostrum; fresh water.........................*exilipes.*
aa. Second pair of legs shorter, hardly reaching the tip of the rostrum; marine...............*vulgaris.*

Palæmonetes carolinus Stimpson. Pl. XXVII, fig. 4.

Palæmonetes carolinus Stimpson, 1874, p. 129; Kingsley, 1878–79, p. 330; Fowler, 1912, p. 328.

Integument moderately firm. Carapace rounded above, anterior margin with suborbital and branchiostegal spines; rostrum slightly exceeding the antennal scales, thin, deep, upcurved in distal half at least, armed above with 8 or 9 teeth and below with 4 or 5, the intervals between the teeth ciliated and the posterior one of the upper surface somewhat removed from the others and belonging, perhaps, to the carapace.

Antennular peduncle shorter than antennal scale; inner flagellum slender; outer flagellum with the basal articles thickened and bearing at about the eighth article an accessory branch of about twelve articles. Antennal flagellum considerably longer than body; scale foliaceous, its sides tapering slightly to an obliquely rounded tip which usually fails to reach the end of the rostrum. First pair of legs short, reaching scarcely beyond the carpus of the second pair. Second pair of legs very long, exceeding the rostrum by almost the length of the hand; fingers a little shorter than the palm. Distal end of fifth legs not extending to the tip of the rostrum.

Abdomen rather stout, bent but not conspicuously humped at the fourth segment. Telson tapering, its sides straight, tip with two long slender spines, upper surface with four small spines.

Length of a female, 24 mm.; carapace, including rostrum, 10 mm.; rostrum, 6 mm.

Color in life, almost transparent; in alcohol, milky white.

It occurs in abundance in the eel grass and about the margins of the marsh in all parts of the harbor, usually in company with *P. vulgaris.*

Palæmonetes vulgaris (Say). Pl. XXVII, fig. 5.

Palæmon vulgaris Say, 1818, p. 248; Coues, 1871, p. 124.

Palæmonetes vulgaris Stimpson, 1871, p. 129; Smith, 1873, p. 550; Kingsley, 1878–79, p. 330; Paulmier, 1905, p. 132; Sumner, 1911, p. 663; Fowler, 1912, p. 324, pl. 94.

Similar to *P. carolinus* except as follows: The dorsal spine of the carapace is lacking or is moved forward until it forms a part of the series of rostral teeth. The tip of the rostrum is more acute, the teeth of the upper margin are smaller and more acute, and those of the lower margin number two or three. The antennular peduncle is as long as the antennal scale. The second pair of legs is much shorter, hardly reaching the tip of the rostrum, and the fingers are considerably shorter than the palm.

Length of a female, 31 mm.; carapace, including rostrum, 12.5 mm.; rostrum, 6 mm.

This species, often found in company with *P. carolinus*, has also been taken frequently in floating *Sargassum.* In August, 1915, it was found in great numbers in a small pool of slightly brackish water close to Newport River about 3 miles north of the laboratory.

Palæmonetes exilipes Stimpson. Pl. XXVII, fig. 3.

?*Hippolyte paludosa* Gibbes, 1850, p. 197.

Palæmonetes paludosa Kingsley, 1878a, p. 97.

Palæmonetes exilipes Stimpson, 1871, p. 130; Smith, 1874, p. 641, pl. 1, fig. 1.

Integument thin and transparent. Carapace subcylindrical, smooth, with slender and acute suborbital and branchiostegal spines; rostrum long, slender, compressed, gently curved upward distally, armed above with 7 or 8 equidistant teeth and below with 2 to 4; second tooth of dorsal margin usually directly above the bases of the ocular peduncles; the tip unarmed, slender, and acute. Outer flagellum of antennule much longer than the inner, the basal portion thick and bearing, at about the sixteenth article, an accessory branch of about seven articles. Antennal flagellum longer than body; scale broad, its rounded tip slightly exceeding the rostrum, its sides nearly parallel. First pair of legs hardly reaching the hand of the second pair of legs and about equaling the antennal scale. Second pair of legs more slender, exceeding the rostrum by more than the length of the hand; fingers a little shorter than the palm. Fifth pair of legs exceeding the tip of the rostrum.

Abdomen rather slender, humped at end of fourth segment. Telson tapering gradually to the extremity where the sides turn in suddenly to end in an acuminate median tooth, on each side of which is a long stout spine and at each lateral angle a much shorter one, while between the inner spines there is a pair of long plumose hairs. The dorsal surface of the telson bears two pairs of spines, one near the distal end and the other one-fourth the distance from the distal end to the base.

Length, 42 mm.; carapace, 18 mm.

Color in life, nearly transparent; in alcohol, milky white.

While *P. exilipes*, being an inhabitant of fresh water, has not been taken in the immediate vicinity of Beaufort, it may be safely predicted that it will be found there sooner or later. It has been collected at Edenton, Wilmington, Hales Point, and Lake Mattamuskeet. It may be readily distinguished from the others of its genus by its much more slender form and slender hands as well as by its habitat.

Genus UROCARIS Stimpson.

Urocaris Stimpson, 1860, p. 39 [108].

Urocaris longicaudata Stimpson. Pl. XXVII, fig. 7.

Urocaris longicaudata Stimpson, 1860, p. 108; Kingsley, 1880a, p. 444; Rathbun, 1901, p. 126.

Integument very thin, transparent, and smooth. Carapace rounded above, its anterior margin with a strong, rounded tooth at the side of the orbit. Rostrum hardly reaching end of second article of antennular peduncle, its upper edge raised into a high, arcuate, 7 to 8 toothed crest, its lower margin with a small spine near tip. Antennal scale exceeding peduncle by about half its length, its margins nearly parallel; apical spine small; flagellum very slender, longer than body. Inner flagellum of antennule with the basal segments thickened and bearing at about the eighth segment a long slender branch almost as long as antenna; inner flagellum simple, more slender and shorter. First pair of legs slender, carpus and hand of nearly equal length. Second pair of legs longer; the carpus, palm, and fingers subequal.

Abdomen strongly bent between third and fourth segments, the posterior part of the third segment extended back like a hood above the fourth. Sixth segment slender and about as long as fourth and fifth combined. Telson narrow, tapering, upper surface with 4 small spines, tip obtuse and bearing several slender spines.

Length of a male, 17 mm.; carapace, including rostrum, 4.2 mm.; rostrum, 1.5 mm.

Found in abundance on submerged eel grass along with *Hippolyte* and *Tozeuma*, where it escapes observation by reason of its almost perfect transparency.

Genus CORALLIOCARIS Stimpson.

Coralliocaris Stimpson, 1860, p. 38 [107].

Coralliocaris wilsoni Hay. Pl. XXVII, fig. 8.

Coralliocaris wilsoni Hay, 1917, p. 71.

Body somewhat compressed, cephalothorax about as long as abdomen excluding telson. Carapace firm, smooth, polished, and with a well-defined postantennal spine; rostrum about one-third as long as remainder of carapace, compressed, slightly decurved and armed above with 11 to 13 acute, equidistant teeth. Eyestalks stout. Antennular flagella of about equal length, the outer much thicker than the inner. Antennal scale broad, equal to the rostrum in length. First pair of legs alike, slender, chelate, the tips of the fingers hairy. Second pair of legs very unequal, the larger one having the chela so large that its bulk is almost equal to the rest of the animal; hand cylindrical, movable finger strongly curved, bent inward, its cutting edge with a prominent lobe near the base; thumb bent downward out of line with the hand, its cutting edge with two slender teeth. Smaller chela about one-third the size of its mate, somewhat compressed but otherwise similarly constructed. Third, fourth, and fifth legs with short, conical dactylus.

Telson narrow, its sides uniformly convergent to the small rounded tip, which bears four slender spines; there is also a spine on each margin near the middle.

Length of body, 16 mm., carapace, 7 mm., large claw, 10 mm.

Color, pellucid, milky white. Egg masses light bluish-green. The integument is so transparent that the color of the internal organs is plainly visible.

Three specimens of this little shrimp, 2 females and 1 male, were obtained August 1, 1914, on the fishing banks about 20 miles off Beaufort Inlet. Another series of 8 or 10 specimens was collected July 20, 1915. In both cases the animals were found in the canals of a large sponge in company with *Synalpheus longicarpus* and *S. townsendi*, to which they bear a striking superficial resemblance. When disturbed or, especially, when dropped into alcohol, they are able to make a snapping sound with the large chela quite as loud as that made by one of the true snapping shrimps.

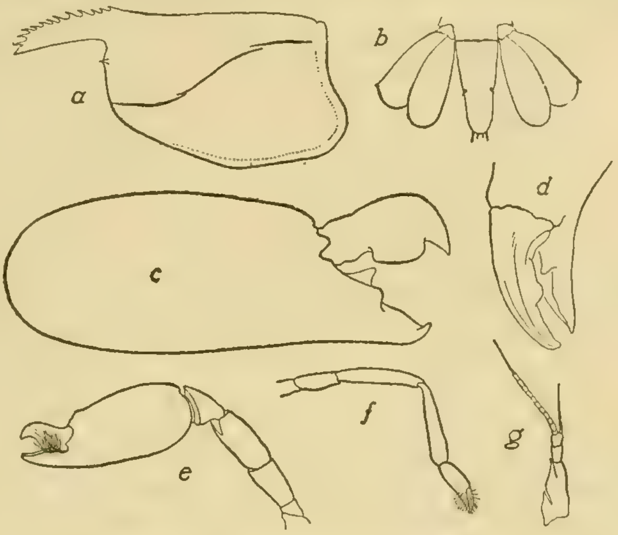

Fig. 13.—*Coralliocaris, wilsoni*, ♂ ×4½.

a, Carapace, lateral view; *b*, telson and uropods; *c*, large chela; outer surface; *d*, fingers of large chela from above; *e*, small chiliped; *f*, right leg of first pair; *g*, antennule.

The species has been dedicated to Dr. H. V. Wilson, of the University of North Carolina, for many years an investigator at the Beaufort station, at one time its director, a well-known authority on sponges, and the one to whom the undertaking of this paper on the decapod crustaceans is largely due.

Family GNATHOPHYLLIDAE.

Caridea having the first two pairs of legs chelate, the first pair smaller than the second, the carpus of the second pair not subdivided, the rostrum short and toothed, the third article of the third maxillipeds very broad, the mandibles simple and the second maxillipeds with a very short seventh article.

The family contains but a single genus.

Genus GNATHOPHYLLUM Latreille.

Gnathophyllum Latreille, 1819, p. 72; (*Gnatophyllum*) ibid, 1829, p.96.
Drimo Risso, 1829, p. 70.

Gnathophyllum modestum Hay. Pl. xxviii, fig. 1.

Gnathophyllum modestum Hay, 1917, p. 72.

Body short and thick. Carapace with a low carina continuous in front with the rostrum and extending about halfway to the posterior margin. Rostrum reaching to distal end of basal article of antennule, obliquely truncate above and with 7 teeth. Suborbital spine acute. Abdomen with the last three segments abruptly smaller and strongly flexed; telson with two marginal spines at about the distal third, the tip almost truncate and with 6 spines, of which the median and longest pair is about one-fifth as long as the telson. Eyes rather large and with a prominent, conical, black protuberance on the cornea. Antennæ about twice as long as carapace. Third maxillipeds with the meral and carpal articles very broad, closing the whole front of the buccal region, the two terminal articles slender and extended straight forward. Second pair of legs much stronger than the first, exceeding the rostrum by the length of the hand; fingers more than half as long as the palm.

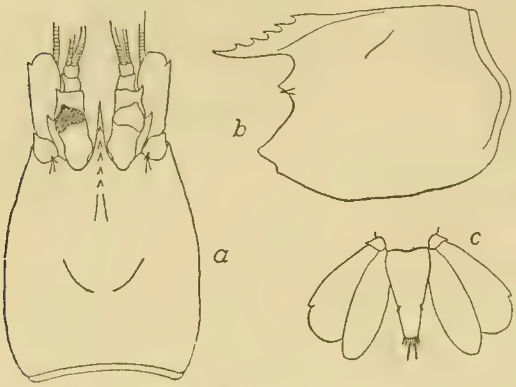

FIG. 14.—*Gnathophyllum modestum*, type. ♀×4½.

a, Dorsal view of cephalothorax; *b*, carapace, lateral view; *c*, telson and uropods.

Length, about 21 mm.; carapace, 8 mm.; rostrum, 2 mm.; hand, 5 mm.

Color: Cephalothorax and abdomen dark brownish-red, telson and tail fins white, eyestalks and peduncles of antennæ and antennules white, flagella of antennæ and antennules and bands on legs purple.

Only one specimen, an ovigerous female, has been collected. It was obtained by the *Fish Hawk* and brought to the laboratory preserved in formalin, but was not noticed until some days later. The color notes were made at once and the specimen transferred to alcohol. Within a few days a spotting or mottling of the surface began to appear, which by the end of the summer had become quite pronounced, but the spots do not have the arrangement described by Faxon in the species *G. panamense*. At no time has there been a suggestion of the bands of color described by Dr. Mary J. Rathbun in *G. americanum*.

A careful comparison of the Beaufort specimen with the two species mentioned and with *G. elegans* shows it to be distinct. It is probably most closely related to *G. panamense*. which it resembles in color pattern, and with which it agrees in length of rostrum and number of rostral teeth. It differs from all hitherto known species, however, in the arrangement of the spines at the tip of the telson. It, furthermore, differs from *G. panamense* in the length of the longer spines at the tip of the telson, in the longer fingers and longer wrist. From *G. americanum* it differs in color and in the much weaker second pair of legs.

Family CRAGONIDAE.

Caridea having the first pair of legs subchelate, the carpus of the second pair not subdivided, the rostrum short and not compressed and the second maxillipeds with a very short seventh article.

This family comprises 13 genera of which only 1, *Crago*, occurs in the Beaufort region.

Genus CRAGO Lamarck.

Crago Lamarck, 1801, p. 159.
Crangon Fabricius, 1798, p. 387. (Not *Crangon* Weber, 1795.)

Crago septemspinosus (Say). Northern shrimp. Pl. XXVII, fig. 9.

Crangon septemspinosum Say, 1818, p. 246.
Crangon vulgaris, Verrill and Smith, 1875, p. 550; R. Rathbun, 1884, p. 816; Paulmier, 1905, p. 131.
Crangon crangon and *Crangon vulgaris* of authors (in part).
Crago septemspinosus Fowler, 1912, p. 320, pl. 93; Sumner, 1911, p. 664.

Integument moderately firm, polished, translucent. Carapace subcylindrical, its dorsal surface with a small appressed spine back of the rostrum; anterior margin with the suborbital angle slightly and the subantennal angle strongly produced, the latter almost spiniform and with a minute spine below it; lateral spine of carapace well developed; anterior part of side of carapace with two impressed lines which originate, one from a fissure in the superior margin of the orbit, and the other at the external canthus, unite above the lateral spine and disappear a little farther back. A third line begins in the fissure at the external canthus and passes below the lateral spine. Rostrum shorter than eyestalks, unarmed, its tip obtuse. First segment of peduncle of antennule with a mucronate scale below the eye; flagella little longer than antennal scale. Antennæ as long as body, slender; scale long, broadest below middle, thence tapering rapidly to the narrow rounded tip; apical spine strong, about as long as distal width of scale. External maxillipeds about as long as antennules, hairy. First pair of legs subchelate, palm with a strong spine at distal end of finger; meros with a small spine on lower margin. Second pair of legs almost filiform, third pair stronger, fourth and fifth pairs normal but comparatively weak. Telson slender, with four small spines above, tip unarmed.

Length of a female, 55 mm.; carapace, including rostrum, 11 mm.; rostrum, 1 mm.

Color, according to Say, pale cinereous, with very numerous irregular, stellate, blackish-brown spots.

In the Beaufort region this shrimp has been supposed to be very rare. The laboratory collection long contained but a single specimen taken in shallow water close to the laboratory. During the early spring of 1914 two additional specimens were taken in the same locality. In the late fall of the same year it was quite frequently taken in the otter trawl in the Morehead Channel, a dozen or more sometimes coming up at one haul. Most of the specimens were ovigerous females whose eggs, in some cases, were nearly ready to hatch.

Suborder REPTANTIA.

Decapod crustaceans, usually of a lobsterlike or crablike form, having the abdomen, whether well developed or greatly reduced, more or less depressed, the first segment distinctly smaller than the rest, and the pleopods, which are not used for swimming, often reduced or wanting. The cephalothorax also is usually depressed and the legs are strong, the first pair usually, the others never, larger than their fellows. Some of the first four pairs of legs rather often bear podobranchs. The rostrum is usually small or wanting; if present it is depressed.

This large and important division of decapod crustaceans, comprising some 700 genera, is divided into the "sections" *Palinura*, *Astacura*, *Anomura*, and *Brachyura*, all of which are represented in the fauna of the Beaufort region.

Section PALINURA.

Reptantia having the abdomen well developed, extended, symmetrical, and well armored, the carapace fused at the sides to the epistome, the legs strong, the third pair being like the first either chelate or simple, the rostrum small or wanting and the gills numerous.

This section comprises two tribes, of which one, *Eryonidea*, does not occur within our limits. The other, *Scyllaridea*, is represented by two species.

Tribe SCYLLARIDEA.

Palinura having the first article of the second antenna fused with the epistome, no antennal scale, all the legs of about the same length and, with the occasional exception of the first pair, none of them chelate, the first abdominal segment without limbs and the tail fin divided by indistinct sutures into a soft hinder half and a harder front half.

This tribe comprises two families, both of which are represented in our fauna.

Family PALINURIDAE.

Scyllaridea having the cephalothorax subcylindrical, the eyes not inclosed in separate orbits formed by the edge of the carapace and the second antennæ provided with flagella.

This family includes 6 genera of which only 1 occurs in our fauna.

Genus PANULIRUS White.

Palinurus White, 1847, p. 69.

Panulirus argus (Latreille). Sea crawfish. Pl. XXVIII, fig. 3.

Palinurus argus Latreille, 1804, t. III, p. 393.
Panulirus argus White, 1847, p. 69; Rathbun, 1901, p. 98.

Carapace as long as the first five abdominal segments, sparsely setose and covered with strong spines arranged in more or less regular longitudinal rows. Spines above the orbits very large, compressed and curved upward and forward. Antennal segment with a pair of spines in front, a weaker pair about halfway to the eye, a strong median spine and weaker lateral ones below the insertion of the antennules.

Abdomen smooth, each segment crossed by a furrow which is more or less distinctly interrupted at the middle. Pleural angles each produced into a strong, sharp, backwardly directed tooth which is deeply notched and toothed on its posterior margin. Proximal division of telson with rather strong spines; distal division with weak spines and cilia in longitudinal lines. Eyes large and prominent. First antenna nearly two-thirds as long as the body, its peduncle slightly exceeding that of the second antenna, outer flagellum shorter and thicker than the inner and strongly ciliate distally. Second antenna very large and heavy, exceeding the body by more than the length of the carapace, its peduncular article with numerous strong spines, its flagellum stout, stiff, with a line of cilia along its inner margin and ringed with spines at intervals.

Legs rather weak, none of them chelate, their tips acute and bristly. Pleopods wanting on the first segment of the abdomen, those of the other somites with a single, broad, membranous lamina. Uropods indurated proximally, membranous distally, the basal article bispinose, a row of denticles along margin of indurated part and lines of minute spines and setæ on upper surface of membranous part.

Color, yellowish and bluish. Abdomen with many small yellow spots; a large yellow spot on each side of the second and sixth segments.

This species, which attains a large size farther south, is rarely represented about Beaufort except by small individuals. These are sometimes taken by fishermen when seining for shrimps in the creeks above the harbor or are caught in dip nets about the wharves in the town, but are of most frequent occurrence outside the inlet. The largest specimen in the laboratory collection measures, exclusive of the antennæ, 90 mm. in length. A much larger specimen, having a body length of 430 mm., was caught near Cape Lookout in the spring of 1916. It was kept alive in an aquarium for about two months.

Family SCYLLARIDAE.

Scyllaridea having the cephalothorax depressed, the eyes inclosed in separate orbits formed by the edge of the carapace and the second antennæ with flat scales in place of flagella.

Of the eight genera now recognized in this family, only one is believed to be represented in the Beaufort fauna.

Genus SCYLLARUS Fabricius.

Scyllarus Fabricius, 1875, p. 413.
Arctus Dana, 1852, p. 516.

Scyllarus americanus (Smith). Pl. XXVIII, fig. 2.

Arctus americanus Smith, 1869, ser. 2, p. 119.
Scyllarus (*Arctus*) *gundlachi* von Martens, 1872, p. 123.
Scyllarus americanus Rathbun, 1901, p. 97.

Integument rugose and hard except for the membranous tips of the uropods and telson. Carapace as long as the first five abdominal segments, its greatest breadth slightly exceeding its length. Dorsal surface with three longitudinal ridges, the median of which has three blunt prominences while the lateral ones are conspicuously broken toward their anterior ends. Margins of carapace more or less dentate and produced anteriorly into a prominent angle which is continued across the front below the orbits so that the latter appear to be excavated in the dorsal surface. Abdomen convex dorsally, rugose; each segment slightly notched on the posterior margin and with a conspicuous impressed line running from near the middle line to the pleural angle. Proximal portion of telson and uropods indurated, the distal half membranous and smoothly rounded. Eyes subspherical, prominent. Antennules biflagellate. Antennæ of four articles, of which the second and fourth are broad thin scales, the anterior margin of the fourth being deeply scalloped. Legs rather small, all simple in the male, fifth pair minutely chelate in the female. Swimmerets of first segment wanting, those of second segment slender and biramous, the others consisting of a single foliaceous branch.

Two specimens of this animal were dredged by the *Fish Hawk* in deep water off Beaufort Inlet. The larger of the two measures 39 mm. from the tip of the antenna to the end of the telson.

Section ASTACURA.

Reptantia having the abdomen extended, well developed, symmetrical, and well armored, the cephalothorax subcylindrical, the carapace free from the epistome, the first three pairs of legs chelate, the first pair much stronger than the rest, the rostrum well developed, and the gills numerous.

Two of the three families which constitute this section are described here.

Family HOMARIDAE (=NEPHROPSIDAE of most authors).

Marine Astacura having the last thoracic segment consolidated with the one in front of it, the pleurobranchs four in number, and with sexual appendages present in the male.

Nine genera are now recognized in this family. Of these only one is, or was formerly, represented in the Beaufort region.

Genus HOMARUS Weber. The lobsters.

Homarus Weber, 1795, p. 94; Milne-Edwards, H., 1837, t. II, p. 333.

Homarus americanus H. Milne-Edwards. American lobster. Pl. XXVIII, fig. 7.

Homarus americanus H. Milne-Edwards, 1837, t. II, p. 334; De Kay, 1844, p. 23; Coues, 1871, p. 124; Kingsley, 1878–79, p. 320; R. Rathbun, 1885, p. 781; Herrick, 1895, p. 1–252; Fowler, 1912, pp. 96–99; Sumner, 1911, p. 665.

Cephalothorax subcylindrical, the carapace smooth and punctate above and on the sides, but with short and acute post orbital, post antennal, and infraorbital spines. Rostrum narrow, decurved until near the tip, which is usually more or less upcurved; margins above with 2 or 3 teeth on each side, lower surface with from 1 to 3 teeth a short distance behind the tip. Abdomen strong, its pleura more or less acuminate and directed backward; telson with a spiniform tooth on each side near the tip; basal article of appendages of sixth segment with two strong denticles. Antennal scale small; antennal flagellum a little longer than body. Chelipeds large and heavy, unequal in size, and with dissimilar chelæ, the broader and heavier one having lobate teeth on the opposable margins of the fingers, while the more slender one has small, sharp teeth and numerous stiff setæ; both chelæ with strong spiniform tubercles on the inner margin in two rows and the base of the movable finger with a tubercle. Walking legs, with pencils of setæ, on the terminal articles.

Color, above dark bluish-green, mottled and speckled with darker spots, merging into dusky yellow or orange on the sides of the carapace and the blades of the tail fin; spines of chelipeds and rostrum, margins of chelæ, and the antennulary and antennal flagella red; walking legs clear bluish-green.

The only record of the occurrence of the lobster in the Beaufort region is by Coues, who stated that a small individual was captured near the town, by fishermen, in the summer of 1870. His surmise, that it might have been thrown overboard from some vessel from the north, may have been correct, but there is good reason to believe that in former years the range of this crustacean extended considerably farther to the south than it does at present. According to Herrick (op. cit., p. 15), "It has been said that lobsters have been seen along the beach in the surf near Indian River Inlet, Delaware. Two or three have been recorded at Johnstown, in the northeastern corner of Virginia, and in October, 1884, the United States Fish Commission steamer *Albatross* obtained a single specimen of good size off Cape Hatteras, North Carolina, from a depth of about 30 fathoms, by means of the beam trawl." De Kay (op. cit., p. 25) stated that in 1814 Gen. Pinckney liberated a car full of lobsters in the harbor of Charleston, S. C., and that survivors of these or their offspring were captured as late as 1830.

At the present time the lobster is not known to occur south of the Delaware breakwater.

Family ASTACIDAE (=POTOMOBIIDAE, of most authors). The fresh-water crawfishes.

Fresh water Astacura, having the last thoracic segment free from the one in front of it, the pleurobranchs wanting or reduced to one on each side, and with sexual appendages present in the male.

Two or three genera are included in this family. Of these, only one is represented in the Beaufort region.

Genus CAMBARUS Erichson.

Cambarus Erichson, 1846, p. 88.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Rostrum long and slender, with lateral teeth near the tip. . . . . *blandingii*.
aa. Rostrum short and broad, without lateral teeth.
  b. Rostrum rather deeply concave above. . . . . *diogenes*.
  bb. Rostrum nearly flat above, with a low carina. . . . . *uhleri*.

Cambarus blandingii (Harlan). Blanding's crawfish. Pl. XXVIII, fig. 5.

Astacus blandingii, Harlan, 1830, p. 464; De Kay, 1844, p. 23.
Cambarus blandingii, Hagen, 1870, p. 43; Faxon, 1885, p. 19; Fowler, 1912, p. 357.

Carapace subcylindrical, smooth above, but with numerous small tubercles on the sides; rostrum elongate, with sharp, raised margins and short lateral spines. Chelipeds slender and thickly tuberculate; chelæ cylindrical and with slender fingers. Walking legs weak, pubescent at the tips, the third and fourth pairs of the male with a hook on the third article. First abdominal appendages of the male club-shaped, with two small, incurved, horny teeth on the distal end of the outer branch and a single backwardly directed spine on the inner branch.

Length, 75 to 80 mm.

Color, dull greenish-brown, whitish beneath and on lower part of carapace, often with a dark greenish longitudinal stripe on the sides; tubercles of chelæ black; sometimes entirely black.

This species is said by Faxon to have been collected at Beaufort, but when and by whom is not stated. Recent collecting has failed to bring it to light in what might fairly be termed the Beaufort region. It has been taken at Lake Matamuskeet and at Wilmington, however, and undoubtedly occurs in the intermediate country. It is an inhabitant of ponds and ditches near the seacoast from New York to Georgia.

Cambarus diogenes Girard. Solitary crawfish. Pl. XXVIII. fig 4.

Cambarus diogenes, Girard, 1852, p. 88; Faxon, 1885, p. 71; ibid., 1914, p. 400; Fowler, 1912, pp. 102–103.

Carapace subcylindrical, compressed anteriorly, without spines and only lightly granulate on the sides; rostrum rather narrow, short, its upper surface rather deeply concave and lightly foveolate at the base. Chelipeds large and heavy; chelæ broad, heavily punctate, fingers ribbed above and below. Third pair of walking legs of the male with a hook on the third article. First abdominal appendages of the male short, strong and twisted, the posterior edge bearded at the base and with two backwardly directed teeth at the distal end. Abdomen shorter than the cephalothorax.

Length, 75 to 80 mm.

Color, very dark brown or olive brown, sometimes almost black; edges of rostrum, postorbital ridges and tips of chelæ and legs orange red.

Although this species had been collected in various other parts of North Carolina it was not until the summer of 1913 that it was met with in the Beaufort region. At that time several specimens were taken from holes which they had dug along the edge of a swamp on the north side of Cullys Creek, 10 or 12 miles north of the laboratory. In most cases these holes were surmounted by low and poorly constructed chimneys.

Cambarus uhleri Faxon. Uhler's crawfish. Pl. XXVIII, fig. 6.

Cambarus uhleri, Faxon, 1884, p. 116; ibid., 1885, p. 77; ibid., 1914, p. 400.

Distinguishable from *C. diogenes* by the rostrum, which in this species is nearly plane above, with a very low and indistinct carina, behind which there is a shallow foveola. The abdomen is commonly longer than the cephalothorax.

Length, 60 to 75 mm.

Color, yellowish or greenish brown, lighter on the sides; rostrum, chelæ, and legs with yellow, or orange.

One or two specimens of this crawfish were secured in 1913 on the south side of Cullys Creek. They were taken from holes which they had dug at the edge of ponds in the woods.

Section ANOMURA.

Reptantia having the abdomen more or less reduced, asymmetrical, flexed beneath the thorax or imperfectly armored but almost always with biramous appendages on the sixth segment; the cephalothorax usually depressed; the carapace free from the epistome; a movable antennal scale often present; the third pair of legs unlike the first and the last pair markedly different from the third.

This section is divided into 4 tribes, all of which are represented in the Beaufort fauna.

Tribe GALATHEIDEA.

Anomura having the abdomen relatively well developed, not closely folded under the thorax, symmetrical and with well-developed pleura, but to some extent not capable of complete extension, the cephalothorax more or less depressed, and the second to fourth pairs of legs with the dactyl not curved and flattened.

Of the 5 families into which this tribe is divided 2 are represented in our fauna.

Family GALATHEIDAE.

Galatheidea having the abdomen not folded under the thorax, the second antennæ with a four-jointed stalk, the arthrobranchs normally placed, and the third maxillipeds with mastigobranchs.

This family comprises 8 genera, of which 2 occur in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Rostrum rather broad, its margins toothed .... *Galathea*.
aa. Rostrum slender, toothless except at extreme base .... *Munida*.

Genus GALATHEA Weber.

Galathea Weber, 1795, p. 94.

Galathea rostrata H. Milne-Edwards. Pl. XXIX, fig. 4.

Galathea rostrata H. Milne-Edwards, 1880, p. 47. H. Milne-Edwards and Bouvier, 1894, p. 252; ibid., 1897, p. 14; Benedict, 1902, p. 303.

Carapace somewhat flattened, crossed by numerous strong, ciliated ridges, its lateral margins with a number of acute spines and its front prolonged into a broad rostrum which is acute at the tip and has four strong, anteriorly projecting spines on each side. Abdomen with cross ridges like those on the carapace but without spines. Chelipeds nearly twice as long as the body, comparatively heavy, with rows of spines or spiniform granules along the margins and appressed, squamiform, ciliated granules on the surfaces; a few larger spines on the carpus and the distal end of the meros; hand a little shorter than the body, fingers gaping widely at the base.

Length, carapace 9 mm.; cheliped, 20 mm.; hand, 10 mm.

A single, much mutilated specimen of this species was obtained, in 1915, by the *Fish Hawk* on the fishing grounds in 14 fathoms. Other specimens, probably from about the same locality, were obtained during the dredging carried on in 1902.

Genus MUNIDA Leach.

Munida Leach, 1820, p. 52.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Abdomen unarmed with spines .... *irrasa*.
aa. Second, third, and fourth abdominal segments with four spines each .... *longipes*.

Munida irrasa H. Milne-Edwards. Pl. XXVIII, fig. 8.

Munida irrasa H. Milne-Edwards, 1880, p. 49; Benedict, 1903, p. 310.
Munida caribæa H. Milne-Edwards and Bouvier, 1897, p. 25.

Carapace spiny in anterior half and adorned with iridescent pubescence. Median rostral spine about twice and lateral rostral spines about half as long as eye. Lateral border with seven spines. No spines on abdomen. Meros of third maxilliped with three spines on the lower margin. Chelipeds three or four times as long as carapace, the meros with rows of spines which are continued onto the carpus and hand. Second pair of legs reaching the proximal end of the hand.

Length of body of a male, 35 mm.; of carapace, 19 mm.; of cheliped, 66 mm.; width of carapace, 11 mm.

Several specimens were obtained by the *Fish Hawk* in 1902 at a depth of 66 fathoms and again in 1914 at a depth of 47 fathoms (station D8249), about 23 miles off Cape Lookout.

Munida longipes H. Milne-Edwards. Pl. XXVIII, fig. 9.

Munida longipes H. Milne-Edwards, 1880, p. 50; H. Milne-Edwards and Bouvier, 1897, p. 44.

Carapace somewhat flattened; front armed with three spines, the two lateral extending a little farther than and the median not quite as far as the eye. There are two gastric spines, placed behind the lateral spines of the front; a small spine about midway between the gastric spine and the lateral border; about six spines on the lateral border, the first the largest; a longitudinal row of three placed to each side of the cardiac region; and two spines on the posterior border. Second, third, and fourth segments of abdomen with four spines each. Eyes large and kidney shaped, their peduncles short. The three anterior pairs of legs more than three times as long as the carapace and armed with many spines.

Length of body, 47 mm.; of carapace, 21 mm.; of chelipeds, 72 mm.; of third pair of legs, 78 mm.; width of carapace, 16 mm.

Several specimens were obtained by the *Fish Hawk* in 1902 at a depth of 172 fathoms (station 7315).

Family PORCELLANIDAE. The porcelain crabs.

Galatheidea, usually of a crablike form, having the abdomen closely folded beneath the thorax, the stalk of the second antenna composed of four articles, the arthrobranchs normally placed, and the third maxillipeds without mastigobranchs.

Of the 8 genera now recognized in this family, 5 have representatives in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Carapace depressed, chelipeds large.
  b. Carapace subcircular, about as broad as long, chelipeds broad and flat.
    c. Epimeral pieces of carapace separated by membranous interspaces; body smooth, hands very rough . . . . *Pachycheles.*
    cc. Epimeral pieces of carapace not separated by membranous interspaces.
      d. Basal article of antenna little developed, the flagellum not excluded from the orbit. *Petrolisthes.*
      dd. Inner angle of basal article of antenna expanded to meet the superior margin of the carapace and excluding the flagellum from the orbit . . . . *Porcellana.*
  bb. Carapace oval, broader than long, hands slender and distorted . . . . *Polyonyx.*
aa. Carapace subcylindrical, much longer than broad, chelipeds small . . . . *Euceramus.*

Genus PORCELLANA Lamarck.

Porcellana Lamarck, 1801, p. 153; restricted by Stimpson, 1858, p. 242.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Body and appendages comparatively smooth . . . . *sayana.*
aa. Body and legs with numerous tuberculate elevations . . . . *soriata.*

Porcellana sayana (Leach). Pl. XXIX, fig. 7.

Pisidia sayana Leach, 1820, p. 54.
Porcellana ocellata Gibbes, 1850, p. 190; Kingsley, 1878, p. 325.
Porcellana sayana Kingsley, 1880, p. 407; Benedict, 1901, p. 137.

Integument minutely granulate, body depressed, carapace a little longer than wide, dorsal surface slightly convex, meeting the lateral parts in a sharp ridge which ends in a slight shoulder a little behind base of antenna. Rostrum triangular, its tip abruptly decurved; orbit with a strong tooth at inner angle separated from the rostrum by a wide and rather deep notch, outer angle much less conspicuous. Cervical groove lightly impressed.

Antennæ slender, longer than carapace. Chelipeds strong and heavy; hand as long as or longer than carapace, its outer margin fringed with long hairs; fingers short, curved and bent. Proximal inner angle of carpus and distal inner angle of meros produced, forming lobes. Second, third, and fourth legs normal; fifth legs reduced and carried above the others. Abdomen weak, much flattened; uropods small and weak; telson divided into about seven small plates by oblique and longitudinal impressions.

Length of a male: Carapace, 9 mm.; hand, 9.5 mm.; width of carapace, 8.5 mm.

Color in life, reddish or rusty brown with irregular longitudinal white lines, of which the median one is broadest and expanded anteriorly; hands and carpi with white spots on a red ground; smaller legs with transverse reddish bars. In alcohol the red color disappears and the animal becomes perfectly white.

Porcellana sayana is not infrequently taken in the dredge in various parts of the harbor and along the neighboring coast. It is most often found in some crevice in a cluster of oyster shells, but is sometimes found as a commensal of the hermit crab (*Pagurus pollicaris*) in the shell of some gastropod. It has also been collected among the rocks of the jetties near Fort Macon.

An account of the zoëa of this crab, secured from eggs hatched at Beaufort, has been given by Brooks and Wilson.[a]

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[a] Johns Hopkins University, Biological studies, vol. II, no. 1, p. 58–64, pl. VI, VII, 1881.

Porcellana soriata Say. Pl. XXIX, fig. 6.

Porcellana soriata Say, 1818, p. 456; Benedict, 1901, p. 137.
Pisidia socia Leach, 1820, p. 54.
Porcellana sociata Gibbes, 1850, p. 190; Kingsley, 1879, p. 407.

Integument firm, areolations of carapace well marked, some of them tuberculate. Carapace hexagonal, slightly wider than long; margins more or less hairy; front, viewed from above, rounded, tridentate from before, the rostrum little, if any, longer than the lateral teeth. Antennæ slender, about as long as carapace.

Chelipeds long and heavy, very tuberculose; hand fringed with hair along lower margin and with the tubercles in rather well-defined rows; fingers with white, strongly hooked tips; carpus with a strong spine and with the tubercles irregularly arranged; under slight magnification the tubercles appear granulate. Second, third, and fourth legs stout, hairy, and with sharp, curved dactyli. Fifth legs vestigial and placed above the others. Abdomen flattened, but of moderate width; telson subtriangular and divided into five regions by well-defined fissures.

Length of carapace, of a male 5 mm.; width, 5.25 mm.

Color in life, a dirty gray; in alcohol, a rusty or grayish red.

Several specimens of this little crab were collected early in the spring of 1912 and two more were secured in July, 1913. In both instances the crabs were found in the canals of sponges washed up on the outer beach of Bogue Bank near Fort Macon. In 1916 two pairs were collected by Mr. O. W. Hyman from the Fort Macon jetty. At the fishing banks the species is common in the larger sponges that are brought up in the dredge. On several occasions 25 or 30 specimens have been collected from one sponge.

Genus PETROLISTHES Stimpson.

Petrolisthes Stimpson, 1858, p. 240.

Petrolisthes galathinus (Bosc). Pl. XXIX, fig. 1.

Porcellana galathina Bosc, 1803, p. 233, pl. 6, fig. 2.
Porcellana sexspinosa Gibbes, 1850, p. 190.
Petrolisthes sexspinosus Stimpson, 1862, p. 73; Kingsley, 1879, p. 405; Benedict, 1901, p. 133.
Petrolisthes galathinus Ortmann, 1897, p. 283.

Carapace a little longer than wide and crossed by numerous ciliated, rugose lines which are best defined anteriorly; front produced into a broad, triangular, sinuous-sided rostrum marked off from the orbit by a notch; supra-orbital and outer orbital spines strong and acute; a strong postorbital spine from which a ridge runs backward a little distance, forming the margin of the carapace, and then turns inward to be lost among the rugæ of the back.

Antennæ about two and a half times as long as the carapace. Meros of third maxilliped with a strong internal spine. Chelipeds large, flattened, crossed obliquely by ciliated rugæ and dentate and ciliate along the outer margin of the hand and carpus; carpus about half as long as hand, its inner margin with five or six strong, serrate spines; movable finger sinuate, its upper margin costate; meros with a spine at the inner distal angle. First, second, and third walking legs with the meros flattened and denticulate on the superior margin; dactyli spinulose. Fourth legs slender and carried on the back.

Length of carapace, 8 mm.; width, 7.5 mm.; length of chela, 10.5 mm.; carpus, 6 mm.

Color in life, grayish brown without markings; in alcohol, light brown with purple or dark-red lines and dots on the rugæ.

Quite a number of specimens of this little crab were taken by the *Fish Hawk* at depths of 6 or 7 fathoms off New River Inlet and off the mouth of the Cape Fear River. One or two of these individuals bore rhizocephalan parasites.

Genus PACHYCHELES Stimpson.

Pachycheles Stimpson, 1858, p. 228.

Pachycheles rugimanus H. Milne-Edwards. Pl. XXIX, fig. 2.

Pachycheles rugimanus H. Milne-Edwards, 1880, p. 36; Benedict, 1901, p. 136.

Carapace slightly longer than wide, flat from side to side, convex from front to back, lightly rugose along the sides; frontal margin projecting downward in an obtuse angle in the middle, hardly visible from above; orbits deeply excavated, their margins slightly raised and their external angle spiniform.

Chelipeds subequal; carpus with four spines, graded in size, the proximal one being the largest; upper surface with four prominent tuberculate ridges with deep channels between; the channels crossed by irregular septæ forming a row of oblong pits between the ridges; the ridges and pitted channels continued onto the hand but with less regularity in their arrangement; fingers tuberculate almost to their tips. First three pairs of walking legs stout and with the three distal articles hairy. Fourth pair weak and borne on the back.

Length of a male, 7.5 mm.; width, 7 mm.

Color, brownish red, the fingers vermilion.

Two specimens of this crab were taken on the fishing banks in 14 fathoms and another off Cape Lookout in 47 fathoms by the *Fish Hawk* in 1914.

Genus POLYONYX Stimpson.

Polyonyx Stimpson, 1858, p. 233.

Polyonyx macrocheles (Gibbes). Pl. XXIX, fig. 8.

Porcellana macrocheles Gibbes, 1850, p. 191.
Polyonyx macrocheles Stimpson, 1857–1860, p. 229; Benedict, 1901, p. 138; Sumner, 1911, p. 669.

Integument firm and smooth. Carapace transversely oval, about one-fourth wider than long; front hardly produced, its margin slightly sinuous; infolded lateral portions separated from the rest of the carapace by a deep fissure. Antenna slender, about one and one-half times as long as body; its basal segment massive, completely filling the fossa in which it is lodged and bearing the flagellum at its outer angle. Chelipeds unequal, long and distorted; hand of the larger one nearly twice as long as carapace; superior margin convex, inferior margin nearly straight and with a fringe of long hairs; fingers short, hooked at tip and toothed on cutting edges, movable one falcate; carpus as long as hand minus the fingers, thick, deeply excavated along front surface to receive the retracted hand; carpus subcubical, likewise excavated in front. Second, third, and fourth legs normal but with short dactyli which bear brushes of stiff hairs. Abdomen small, much flattened; uropods small; telson divided into small plates.

Measurements of a male: Length of carapace, 7 mm.; width of carapace, 9.25 mm.; length of hand, 13 mm.

Color, grayish white, sometimes stained with brown.

This curious little crab is a common commensal of *Chætopterus pergamentaceus* whose U-shaped tubes may be found imbedded in the shoals in various parts of the harbor. It is very rarely found outside these tubes; in fact when grown, it is probably impossible for it to escape from the tube in which it has taken up its abode.[a] A male and a female are usually found together in the end of the tube opposite the one occupied by the worm. The breeding season extends through the whole summer, females carrying eggs having been collected from June 21 to October 25.

Genus EUCERAMUS Stimpson.

Euceramus Stimpson, 1860, p. 445.

Euceramus prælongus Stimpson. Pl. XXIX, fig. 3.

Euceramus prælongus Stimpson, 1860, p. 445; Kingsley, 1878–79, p. 408; Benedict, 1901, p. 138.

Carapace subcylindrical, elongate, the sides slightly arcuate, with minute irregular, transverse rugæ anteriorly; anterolateral margins with two spines on each side behind the antennæ; front tridentate, the median spine being about twice as long as the lateral ones. Eyes well developed but almost concealed beneath the front. Antennules very short. Antennæ about three-fourths as long as body, their flagella sparsely covered with very fine hairs. Third maxillipeds large and forming a subquadrate shield which extends laterally almost to the edge of the carapace. Chelipeds stout; hand slightly roughened and hairy; fingers about as long as palm, not gaping. Second pair of legs shorter than the third and fourth pairs. Fifth pair reduced and turned dorsally. Abdomen small, its distal segments very narrow and the uropods vestigial.

Measurements: Length of carapace, 8 mm.; width of carapace, 3.75 mm.

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[a] Enders: Notes on the commensals found in the tubes of *Chætopterus pergamentaceus*, American Naturalist, vol. XXXIX, p. 37–40, 1905.

This little crustacean appears to be one of great rarity in the Beaufort region and for a number of years has not been taken at all. In the collection of the laboratory of the Bureau of Fisheries there is a single mutilated specimen without any data. Another was taken, but unfortunately lost, during the summer of 1914 while the *Fish Hawk* was dredging in Lookout Bight. The species was originally described by Stimpson from a specimen obtained at Beaufort and was later collected by Prof. Webster and recorded by Kingsley.

Tribe THALASSINIDEA.

Anomura of a somewhat shrimplike form having the cephalothorax compressed, the abdomen large, symmetrical, extended and sometimes with well-developed pleura, and the appendages of the sixth segment usually adapted for swimming. The carapace and the covering of the abdomen are often more or less membranous and the last articles of the second to fourth pairs of legs are not curved and flattened.

This tribe comprises 4 families of which 1 is represented in the Beaufort fauna.

Family CALLIANASSIDAE.

Thalassinidea having a "*linea thalassinica*," small abdominal pleura, no sutures on the sixth abdominal appendages, no podobranchs on any of the legs, and broad appendage on the third to sixth abdominal segments.

Of 13 genera, 3 are represented in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Rostrum small; first two pairs of pleopods different from the following three pairs; chelipeds dissimilar and unequal.
  b. Inner blade of uropods oval; telson nearly flat above .... *Callianassa.*
  bb. Inner blade of uropods narrow, its margins nearly parallel; upper surface of telson with a deep median groove .... *Callichirus.*
aa. Rostrum large; second pair of pleopods like the following three pairs; chelipeds alike and subequal .... *Upogebia.*

Genus CALLIANASSA Leach.

Callianassa Leach, 1814, p. 400.

Callianassa stimpsoni Smith. Pl. XXIX, fig. 5.

Callianassa stimpsoni Smith, 1873, p. 549; Kingsley, 1880a, p. 410; Sumner, 1911, p. 666.

Integument throughout smooth and shining, thin, but more than membranaceous. Cephalothorax about one-third the length of the abdomen, very thin shelled on the sides but with an oval, thickened plate on the dorsal region; rostrum and postorbital spines subequal, small and acute. Abdomen with the third, fourth, and fifth segments of about the same width and each with a small patch of fine hairs on the posterolateral angle; sixth segment narrowing; telson small, flat, rounded. Eyestalks small, flat, pointed, and with the tips curved outward. Antennular peduncle about two-thirds as long as the carapace, densely ciliate beneath, the flagella about as long as the distal article of the peduncle. Antenna slender, longer than the cephalothorax, its peduncle geniculate between the second and third articles. First pair of legs in the male very dissimilar; the larger one with a prominent tooth at the proximal end of the meros beneath; carpus articulating with meros by the extreme upper angle, its width equal to that of hand; fingers of about equal length, hairy and with incurved tips. Uropods with both blades broad.

Length of a male, 59 mm.; carapace, 14.5 mm.

Although recorded by Kingsley in 1879, this crustacean was not met with again in the Beaufort region until 1914, when a small specimen was brought in from the Blackfish Banks by the steamer *Fish Hawk*.

Genus CALLICHIRUS Stimpson.

Callichirus Stimpson, 1866, p. 47.

Callichirus major (Say). Pl. XXIX, fig. 10.

Callianassa major Say, 1818, p. 238; Gibbes, 1850, p. 194; Coues and Yarrow, 1878, p. 378.
Callichirus major Stimpson, 1866, p. 47; ibid 1871, p. 122.

Integument throughout more or less thin and membranaceous, the most indurated portions being the chelipeds and an oval plate covering the anterior three-fourths of the carapace. Rostrum very small, obtuse, and with a slightly smaller projecting lobe on each side of it on the margin of the front. Eyes minute, situated at about the middle of the outer margin of the flattened and pointed peduncles. Antennular peduncles about two-thirds as long as carapace, stout, densely ciliate beneath, each with two flagella about as long as the distal article of the peduncle. Antenna slender, longer than cephalothorax, the peduncle geniculate between the second and third articles. First three pairs of legs much compressed, the margins of the distal articles especially sharp. First pair of legs probably dissimilar, the larger one in the specimen missing; the remaining one, on the right side, with the chela rather small; fingers weak and meeting only at their tips; carpus as long as hand and somewhat wider. Second legs with long cilia on lower margin; chela short and triangular. Third legs with the penultimate article transverse, it and the small triangular dactyl densely ciliate. Fourth and fifth legs subcylindrical; propodi and dactyl ciliate.

Abdomen long, gradually widening from the body to the third segment and thence narrowing slightly to the sixth. Sixth segment deeply grooved above. Uropod with the outer branch broad, rounded at the tip and ciliate on its distal half while the inner one is very narrow, almost parallel sided, obliquely truncate and ciliate at the tip only. Telson with an inflated area on each side distally, giving it the appearance of being deeply notched or fissured.

Length: Tip of rostrum to tip of telson, 96 mm.; carapace, 21 mm.; antenna, 30 mm.; telson, 8 mm.

Color, (in alcohol) white, the cilia everywhere dark brown.

The somewhat mutilated specimen from which this description was written has been in the museum in the United States Fisheries biological station, Beaufort, N. C., for many years. It is without data as to time and place of collection, but there is no doubt that it came from somewhere in the neighborhood of Beaufort.

A careful comparison with Say's description reveals a number of apparent differences which have tempted those who have examined it to regard it as a distinct species. Say attributes to *C. major* small eyes placed on the upper side of cylindrical, obtuse peduncles, a rostrum having the form of a very small, projecting, acute angle, and a telson rounded at the tip. In the main his description fits this specimen very well, and it is believed that the discrepancies are to be attributed to Say's choice of words rather than to real structural differences in the animals. Unfortunately Say's specimens, which came from the banks of St. Johns River, Fla., have been lost and no others have been collected in that region.

Gibbes (*loc. cit.*) stated that he had specimens of *C. major* from the coast of South Carolina and Charleston Harbor and that he regarded them as identical with the species described by De Kay[a] as *Gonodactylus setimanus*. He mentioned specimens in the Charleston museum and in the museum of the Lyceum of Natural History of New York. Unfortunately all of these specimens appear to have been lost, and it is therefore impossible to pass upon the accuracy of Gibbes's identifications.

The specimens upon which Coues and Yarrow based their statement that *C. major* belongs to the Beaufort fauna have likewise disappeared. In fact the specimen from which the present description was taken is believed to be the only one in existence that at all approaches Say's *Callianassa* (*Callichirus*) *major* and until there is proof to the contrary it will be best to regard it as belonging to that species.

According to Say's account the animal is common along the coast of the Southern States. "It lives in burrows which penetrate the sand to a depth of 18 inches or more. The mouths of these burrows are near low-water mark and often project, like a small chimney, half an inch or more above the surface of the sand. While the exuviæ, especially of the large cheliped, occur frequently on the sea beach in the early spring, the animals themselves are seldom seen and are usually to be obtained only by digging."

In the Beaufort region the species is certainly one of the greatest rarity, for, in spite of the energetic work of many collectors through many years, only one specimen has been found.

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[a] Nat. Hist. N. Y. Crust., vol. 34.

Genus UPOGEBIA Leach.

Upogebia Leach, 1814, p. 400.

Upogebia affinis (Say). Pl. XXIX, fig. 9.

Gebia affinis Say, 1818, p. 241; Kingsley, 1880, p. 410.
Upogebia affinis Stebbing, 1893, p. 185; Sumner, 1911, p. 666; Fowler, 1912, p. 108.

Integument, save that of the dorsal part of the carapace and of the legs, more or less membranous. Carapace about half as long as abdomen, its cephalic portion about twice as long as the thoracic; nearly flat above; anteriorly rugose, covered with short, rigid hairs and terminating in three acute points of which the median considerably exceeds the lateral ones; a small, upcurved spine behind the eye; a minute lateral spine just behind the cervical groove.

Abdomen gradually increasing in width to the fourth segment. Fifth segment much narrower posteriorly; sixth subquadrate. Lateral parts of third and fourth segments densely pubescent and all with their pleuræ marked off by an impressed line. Telson broad, subquadrate, with an impressed median line. Caudal lamellæ small, the inner one truncate and with a median rib and costate outer border; the outer one rounded at tip and with two ridges.

Eyestalks concealed, pubescent above; corneal surface small. Antennæ a little less than twice as long as carapace. Chelipeds stout; chelæ fringed with long hairs beneath, with an external dentate ridge above, a median row of acute spines and an internal line of stiff hairs; immovable finger smooth, curved and with a small tooth near the middle; movable finger much longer, denticulate above at base; carpus grooved on outer face, with a row of small spines below, a row of small teeth above on inner margin, six acute spines along the distal margin above and a strong marginal spine below; meros with a small spine above and a fringe of long hairs beneath. First pair of walking legs ciliate at tips and along lower margin; fourth article with a strong spine at base. Second, third, and fourth legs ciliate at tips.

Length, 40 to 60 mm.

Color, a light gray or yellowish gray, the cilia darker.

At Beaufort this crustacean occurs in various parts of the harbor in burrows which it digs to a depth of about a foot in muddy sand between tide levels. The margins of Town Marsh, of Pivers Island, and the projecting shoal above the fish factory are favorable collecting grounds. In the latter locality an hour's work at low tide has brought to light as many as 50 specimens ranging from very young to full-grown individuals. Females carrying eggs may be collected at almost any time during the summer. A small percentage of the adults have been found to carry a large isopod parasite (*Pesudione upogebiæ* Hay)[a] in the right or left branchial chamber.

Tribe PAGURIDEA.

Anomura having the abdomen usually well developed but nearly always asymmetrical, soft and twisted or bent under the thorax, and with the appendages of its sixth segment, when present, adapted for holding the body in hollow objects.

This tribe includes 4 families, 1 of which is represented within the Beaufort limits.

Family PAGURIDAE. The hermit crabs.

Marine Paguridea having an asymmetrical, soft, spirally twisted abdomen whose appendages, except those of the sixth segment, are greatly reduced in size or wanting; the antennal scale is thornlike, the stalks of the first antennæ are of moderate length and their flagella end in a filament.

Of 31 genera, 7 occur in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.[b]

a. External maxillipeds approximated at base; chelipeds subequal or the left is much larger than the right; very rarely is the right slightly, never is it much, larger than the left. . (Subfamily *Dardaninæ*).

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[a] Hay: Proc. U. S. Nat. Mus., vol. 41, p. 572, 1916.

[b] This key is taken, with modifications, from Alcock, Cat. Ind. Decapod. Crust. in Indian Mus., part II, 1905.

b. Paired appendages present on the first two abdominal segments of the male and the first segment of the female . . . . *Paguristes*.
bb. No paired appendages on the first abdominal segment of either sex.
c. Fingers of chelipeds opening and closing horizontally . . . . *Clibanarius*.
cc. Fingers opening and closing obliquely or nearly vertically . . . . *Petrochirus*.
aa. External maxillipeds widely separated at base by a sternum; right cheliped usually much larger than the left, the left never larger than the right; occasionally they are subequal (Subfamily *Pagurinæ*).
b. Fingers opening and closing obliquely; vas deferens not protruding; first abdominal segment of female only with a pair of appendages . . . . *Pylopagurus*.
bb. Fingers opening and closing horizontally; first abdominal segment without paired appendages in either sex.
c. Vas deferens not protruding in the form of a tube . . . . *Pagurus*.
cc. Vas deferens produced on the right side only into a tube which recurves over onto the dorsum of the abdomen . . . . *Catapagurus*.

Genus PAGURISTES Dana.

Paguristes Dana, 1852, p. 436; ibid., 1852, p. 269.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Anterior portion of carapace wider than long, carpus and hands rather thickly covered with long, soft hair . . . . *moorei*.
aa. Anterior portion of carapace longer than wide, carpus and hands with scattered short hairs . . *armatus*.

Paguristes moorei Benedict. Pl. xxx, fig. 3.

Paguristes moorei Benedict, 1901, p. 144, pl. 4, fig. 3.

Anterior division of carapace broader than long, its anterior margin with three projections—a rounded median one (rostrum) and a pair of slightly more advanced and more acute lateral ones; upper surface with a few scattered hairs and more or less iridescent. Eyestalks almost parallel sided, slightly dilated at the corneal end, straight or slightly curved outward; scale small, blunt-tipped. Antennal peduncle extending slightly beyond middle of eyestalk; flagellum short, not exceeding the tips of the legs. Antennulary peduncle not quite reaching the end of the eyestalk. Chelipeds subequal in size and of similar form, the chelæ short and thick; upper surface of carpus and hand with a covering of long, soft hair, which almost hides the spinules and sharp tubercles beneath; inner superior margin of hand with a row of five small, stout spines; carpus with two rows and meros with one row of spines above. First pair of walking legs with a row of spines along the upper margin of the carpus and propodus.

Length, 13 mm.; carapace, 5 mm.

Color, yellowish, the eyestalks deep orange or crimson below and white above.

A single small specimen of this species was brought in by the *Fish Hawk* in 1915 from the margin of the Gulf Stream about 30 miles due south of the Cape Lookout Lightship.

Paguristes armatus Hay. Pl. xxx, fig. 7.

Paguristes armatus Hay, 1917, p. 73.

Anterior division of carapace considerably longer than wide, its front margin thickened and drawn out into an almost straight-sided, acute rostrum whose tip considerably exceeds the rather obtuse lateral projections. Eyestalks considerably longer than greatest width, but not quite equal to the length of the anterior division of the carapace, nearly straight and not much enlarged distally; scale acute. Peduncle of antennule slightly longer than eyestalk. Peduncle of antenna about two-thirds as long as eyestalk; acicle straight, spinulose from base to tip. Chelipeds not very unlike in size, and similar in form, short, thick; meros, with a few spines distally; carpus and hand covered with strong, sharp-pointed, conical tubercles, of which those on the upper margin of the movable finger, palm, and carpus are larger than the others. Carpus and propodus and to some extent the dactyli of the first pair of walking legs spinulose along the upper and lower margins.

Length, about 20 mm.; carapace, 8.5 mm.

Color, in alcohol, nearly white; each cheliped with a conspicuous orange-yellow band across the meros; a faint trace of a similar band on each of the walking legs.

A single specimen of this species was obtained by the *Fish Hawk* from the margin of the Gulf Stream, 30 miles south of the Cape Lookout Lightship. It is rather closely related to *P. spinipes* H. Milne-Edwards, but differs in having much shorter eyestalks and differently formed hands.

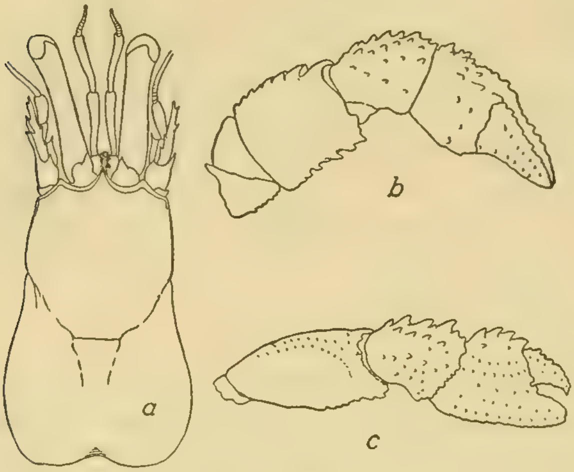

FIG. 15.—*Paguristes armatus*, type. ×4½.

a, Dorsal view of carapace and frontal appendages; *b*, left cheliped, from above; *c*, right cheliped.

Genus CLIBANARIUS Dana.

Clibanarius Dana, 1852, p. 6.

Clibanarius vittatus (Bosc). Striped hermit crab. Pl. XXX, fig. 9.

Pagurus vittatus Bosc., 1802, p. 78; H. Milne-Edwards, 1837, t. II, p. 237.
Clibanarius vittatus Stimpson, 1858, p. 235; Kingsley, 1878–79, p. 326.

Anterior division of carapace subquadrate; front with the rostrum slightly more prominent than the lateral projections. Eyestalks long, slender, slightly exceeding the peduncles of the antennules, nearly cylindrical and curved very little; cornea not dilated, scale small, pointed, its margin serrate. Antennal peduncles about equal to those of antennules, acicle acute and serrate along the margin. Chelipeds similar on the two sides; hand thick, inflated, covered thickly above and sparingly below with coarse tubercles from the base of each of which springs a bundle of stiff hairs; fingers heavy, gaping at the base, cutting edge corneous and extending along the upper side; carpus as long as hand to base of thumb, its upper surface with spiniform tubercles and hairs. Second and third pairs of legs exceeding the chelipeds by over half the length of the dactyli; their tips corneous and the two distal articles with numerous bundles of hairs. Fourth and fifth pairs of legs reduced, the fifth ones very small and turned onto the back.

Measurements of a female: Length of carapace, 28.5 mm.; eyestalks, 12.5 mm.; hand, 18 mm.; width of front, 5.5 mm.

Color in life, light olive-gray, with longitudinal stripes of darker color on the three anterior pairs of legs. In alcohol the dark stripes on the legs become brownish red.

This hermit crab is common throughout the harbor. It may be recognized at once by its symmetrical claws.

Genus PETROCHIRUS Stimpson.

Petrochirus Stimpson, 1858, p. 233(71).

Petrochirus bahamensis (Herbst). Pl. XXX, fig. 6.

Cancer bahamensis Herbst, 1796, p. 30.
Pagurus granulatus Olivier, 1811, p. 640; H. Milne-Edwards, 1834–1840, t. II, p. 225; Dana, 1852, p. 453; Henderson, 1888, p. 56.
Petrochirus granulatus Stimpson, 1858, p. 71.
Petrochirus bahamensis Benedict, 1901, p. 140.

Anterior division of carapace flattened, rough and uneven and with scattered tufts of hairs; front tridentate, the rostrum about as long as the lateral teeth. Eyestalks one and three-fourths as long as distance between lateral teeth of front, straight, dilated distally and with a tuft of hairs above the corneal surface; scale small, its anterior margin serrate. Antennular peduncles exceeding eyestalks. Antennal peduncles shorter than eyestalks, acicle rather slender and with bundles of hairs. Chelipeds nearly equal in size, the right slightly larger than the left; hands and carpi coarsely tuberculate, the tubercles dentate and setiferous on the upper surface, but becoming spinous along the inner margin. Second and third pairs of legs slender, slightly exceeding the chelipeds and with the two distal articles hairy. Fourth and fifth pairs of legs reduced, the fifth pair turned up against the side.

Measurements of a male: Length of carapace, 12.5 mm.; eyestalks, 5.8 mm.; hand, 12 mm.; width of front, 2.8 mm.

This species has been secured by dredging in 8 to 12 fathoms 4 or 5 miles off Beaufort Inlet.

Genus PAGURUS Fabricius.

Pagurus Fabricius, 1793, p. 468.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Eyestalks with the cornea dilated.
  b. Hands broad and flat; species reaching a rather large size.............................*pollicaris*.
  bb. Hands subcylindrical; chelipeds rather slender; small species.
    c. Carpus as long as the palm and half the finger.................................*longicarpus*.
    cc. Carpus barely longer than the palm..*corallinus*.
aa. Eyestalks with the cornea not dilated.
  b. Eyestalks reaching almost to the end of the antennular peduncle.....................*annulipes*.
  bb. Eyestalks much shorter than the antennular peduncle.................................*cokeri*.

Pagurus pollicaris Say. Pl. XXX, fig. 1.

Pagurus pollicaris Say, 1817, p. 162; H. Milne-Edwards, 1834–1840, t. II, p. 37; De Kay, 1844, pp. 19, 21; Sumner, 1911, p. 666; Fowler, 1912, p. 371, pl. 11, fig. 1.
Eupagurus pollicaris Stimpson, 1858, p. 237; Coues, 1871, p. 124; Kingsley, 1878–79, p. 327; Paulmier, 1905, p. 136.

Anterior division of thorax subcordate, truncate behind; front with three projections, of which the rostrum is slightly less advanced and more obtuse than the lateral ones. Eyestalk moderately stout, one and one-half times as long as width of front, nearly straight, the cornea dilated; scale broad, with blunt tips. Antennular peduncle exceeding eye by about three-fourths the length of the distal article. Antennal peduncle about as long as that of antennule; acicle slender, curved outward. Right cheliped stout; its hand flattened, rather finely granulate and tuberculate, crested and dentate along lower margin to tip of immovable finger; movable finger with a prominent, projecting angle on outer border; carpus with numerous tubercles larger than those of the hand, subspinous and ciliated on upper surface; meros with a few squamiform tubercles. Left cheliped similar but with both margins of hand dentate, the movable finger not produced and the dentation of the inner margin of the hand carried onto the carpus. Second and third pairs of legs strong; fourth pair reduced; fifth pair reduced and carried on the back.

Measurements of a male: Length of carapace, 14 mm.; eyestalks, 6 mm.; hand, 12.5 mm.; width of front, 4 mm.

This hermit crab has been collected in nearly all parts of the harbor but prefers the deeper channels. It may readily be distinguished from the other hermits of the region by its large, broad, dissimilar hands.

Pagurus longicarpus Say. Pl. XXIX, fig. 13.

Pagurus longicarpus Say, 1817, p. 163; Gould, 1841, p. 330; De Kay, 1843, p. 22; Sumner, 1911, p. 667; Fowler, 1912, p. 373.
Eupagurus longicarpus Stimpson, 1858, p. 237; Kingsley, 1878–79, p. 326; Paulmier, 1905 p. 136.
Eupagurus longipes, Coues, 1871, p. 124.

Anterior division of thorax subcordate, truncate behind; rostrum considerably less prominent and less acute than the lateral teeth of the front. Eyestalks stout, one and one-third times as long as width of front, cornea dilated; scale broad with blunt tip. Antennular peduncle exceeding eye by about one-half the length of the terminal article. Antennal peduncle shorter than that of the antennule, acicle slender, curved outward. Right cheliped much longer and larger than the left, subcylindrical; hand short, very lightly crested and minutely dentate along outer margin, upper surface minutely granulate and with two incomplete rows of larger granules near proximal end; fingers short, hooked at tips; carpus as long as hand to middle of finger, with small scattered tubercles and two rows of subspinous larger ones. Left cheliped similarly formed but with relatively broader, unhooked fingers. Second and third legs slender, extending about as far as the chelipeds. Fourth and fifth pairs much reduced, the latter turned upward onto the back.

Measurements of a male: Length of carapace, 7 mm.; eyestalks, 3 mm.; hand, 8 mm.; width of front, 2 mm.

Pagurus longicarpus is by far the commonest hermit crab of the region and occurs in nearly every locality examined. It is most abundant, however, in the channels whence, by dredging, hundreds may be taken in a few hours.

Pagurus corallinus (Benedict). Pl. XXX, fig. 4.

Eupagurus corallinus Benedict, 1892, p. 23.

Anterior division of carapace subcordate, truncate behind; rostrum obtuse, much produced beyond the rounded, unarmed lateral projections. Eyestalk falling far short of the tip of the antennulary peduncle, stout, largest distally; cornea dilated; scale sharp-pointed and with a prominent subterminal spine. Antennal peduncle about as long as that of the antennule, acicle about equaling eye. Large cheliped with the meros compressed, quadrilateral when seen from the side; carpus a little longer than palm, its upper surface thickly set with sharp spiny granules, its margin with rows of small spines; hand fringed with spines alternately large and small, the spines becoming longer near the tips of the fingers, entire upper surface set with small, slender spines. Smaller cheliped with the meros much compressed; carpus compressed and surmounted by an inner row of small and an outer row of larger spines; hand, wide and compressed; fingers broad and gaping at the base; carpal and propodal articles of the first and the carpal article of the second walking leg crested with acute spines.

Color white, the large cheliped blotched with red, the other legs banded with the same color.

One small specimen about 15 mm. long was dredged by the *Fish Hawk* in 47 fathoms off Cape Lookout. The large cheliped is missing, but the specimen agrees so perfectly in all that remains with Dr. Benedict's descriptions that his words regarding the missing part have been included in this description. The species has been known previous to this from Key West.

Pagurus annulipes (Stimpson). Pl. XXIX, fig. 12.

Eupagurus annulipes Stimpson, 1860, p. 243; Kingsley, 1878–79, p. 326; Sumner, 1911, p. 666.

Anterior division of carapace subcordate, truncate behind; rostrum arcuate, lateral angles of front obtuse. Eyestalk extending nearly to tip of antennular peduncle, slightly constricted in the middle, cornea not dilated; scale broad and rounded, but with one or two minute spines on anterior border. Antennal peduncle shorter than that of antennule; acicle slender, hairy, curved outward. Right cheliped very long, subcylindrical, moderately and evenly granulate above and finely ciliate; hand somewhat inflated; fingers short and with hooked tips; carpus as long as palm of hand, spinulose along inner margin. Left cheliped much shorter than the right, thickly ciliate and spinulose above; hand shorter than carpus; fingers shorter than palm, weak and slightly gaping. Second and third legs of right side as long as cheliped, ciliate to their tips; those of left side similar, but slightly shorter. Fourth legs much reduced. Fifth pair smaller and carried on dorsal surface.

Measurements of a male: Length of carapace, 3 mm.; eyestalk, 1.2 mm.; hand, 3.5 mm.; width of front, 1 mm.

This little hermit crab, while not as abundant as *P. longicarpus*, is not uncommon on shelly bottoms in the channels of the harbor and along the coast. When living, its appendages are marked with alternate rings of white and brown.

Pagurus cokeri Hay. Pl. XXX, fig. 2.

Pagurus cokeri Hay, 1917, p. 73.

Anterior portion of carapace as long as broad, its anterior margin with three projections of which the middle one is decidedly more advanced and is terminated by a spine about twice as large as the spines of the lateral ones; a little behind the frontal margin and parallel with it there is an irregular line of stiff hairs. Eyestalks short and stout, their length equal to about twice the diameter of the cornea; scale small, its tip spinulose. Peduncle of antennule about one and three-fourths times as long as eyestalks. Antennal peduncle a little shorter than that of antennule, its basal article with a small lateral spine curved downward and forward, its second article with a spine on the inner distal angle and several spinules on the inner side of the outer distal prolongation; acicle curved; flagellum slender, longer than the body. Chelipeds hairy; meros and carpus nearly smooth except for a few spines along the margins, chelæ with the entire upper surface spinulose, the spinules being placed quite close to one another and each with a cluster of stiff hairs at the base on the distal side; the right cheliped is much larger than the left and its hand has the finger and palm of about equal lengths; in the left hand the finger is about four times as long as the palm and when closed meets the thumb for only a short distance near the tip.

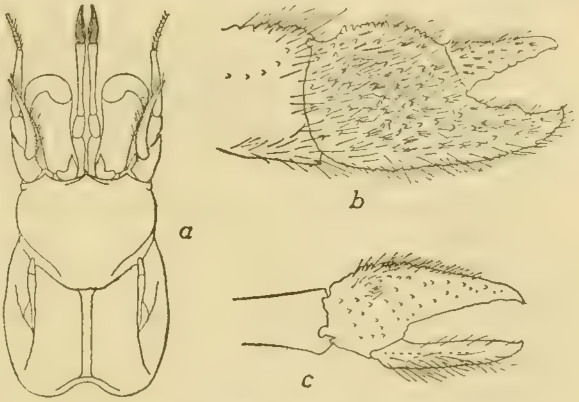

Fig. 16.—*Pagurus cokeri*, type, ♀×4½.

a, Dorsal view of carapace and frontal appendages, the basal articles of the antennules considerably foreshortened; *b*, right chela; *c*, left chela.

Length: About 29 mm.; carapace, 11 mm.

Two specimens of this hermit crab were dredged by the *Fish Hawk* from the margin of the Gulf Stream at a point 30 miles south of Cape Lookout Lightship. The species is most closely related to *P. bouvieri* (Fax) [=*smithii* Milne-Edwards and Bouvier] from which it differs, however, in the spines on the antennal peduncle, the length of the movable finger as compared with the palm of the small hand and the gaping fingers. The species has been named in honor of Dr. R. E. Coker, of the Bureau of Fisheries, one time biologist of the North Carolina Geological Survey at Beaufort, and a contributor to the literature on the fauna of the region.

Genus PYLOPAGURUS A. Milne-Edwards and Bouvier.

Pylopagurus A. Milne-Edwards and Bouvier, 1893, p. 74.

Pylopagurus rosaceus A. Milne-Edwards and Bouvier. Pl. xxx, fig. 5.

Pylopagurus rosaceus A. Milne-Edwards and Bouvier, 1893, p. 74.

Anterior division of carapace about as long as broad, its anterior margin with three projections, the median one (rostrum) obtuse and slightly advanced beyond the lateral ones, which terminate in a minute spine; sides of dorsal surface and anterior margin with a few tufts of setæ. Eyestalks stout, considerably shorter than the anterior division of the carapace, distinctly dilated at the distal end and with three or four pencils of setæ in line along the upper surface, eye scale small, its tip acute. Antennal peduncle extending beyond the eye, flagellum slender and longer than the body, acicle strongly curved. Right cheliped very much larger than the left; chelæ in both hands capable of being bent down at a right angle to the carpus so as to form, either singly or together, an operculum to close the orifice of the cavity inhabited by the crab; both margins of large chela and outer margin of small one armed with a row of close-set conical teeth and the upper surface of both covered with closely crowded rosettelike tubercles each of which consist of a central larger tubercle surrounded by a number of smaller ones. Walking legs of medium length, the first and second on the left side and the second on the right side exceeding the large chela.

Length of a male, about 24 mm., carapace, 9 mm.

Two specimens of this hermit crab were obtained by the *Fish Hawk* in 1915 from the margin of the Gulf Stream about 30 miles south of Cape Lookout Lightship.

Genus CATAPAGURUS A. Milne-Edwards.

Catapagurus A. Milne-Edwards, 1880, p. 46.

Catapagurus sharreri A. Milne-Edwards. Pl. XXIX, fig. 11.

Catapagurus sharreri A. Milne-Edwards, 1880, p. 46; Smith, 1883, p. 31, pl. 4, fig. 5; ibid, 1884, p. 353, pl. IV, fig. 1–2; ibid, 1886, p. 642.
Hemipagurus socialis, Smith, 1881, p. 423.

Carapace convex, rugose on the gastric region. Ocular peduncles rather short and thick; ophthalmic scales less than half as long as the peduncles, narrow and acute. Chelipeds slender, the right a little longer and considerably stouter than the left; hand with the internal surface covered with long hairs; movable finger with a large tooth near the middle. Second and third pairs of legs nearly equal in length and slightly exceeding the chelipeds, their meral articles spinulose on the margins, their dactyli compressed and ciliated.

Measurements of a male (type): Length, 13 mm.; eyestalks, 2 mm.; right chela, 8 mm.; left chela, 7.5 mm. (Smith).

This species has been collected at various points along the Atlantic coast from Massachusetts to the mouth of the Chesapeake. The type specimens came from the Barbados. It is usually found at greater depths than 100 fathoms, but has been taken in less than 60 fathoms. It was dredged by the *Fish Hawk* in 1902, in 151 fathoms, off Cape Lookout.

This hermit crab is sometimes found in a naked shell of some gastropod, but usually the shell is completely overgrown and finally removed by a colony of *Epizoanthus americanus*.

Tribe HIPPIDEA.

Anomura having the abdomen reduced in size and bent under the thorax, the appendages of the sixth segment not adapted for swimming, the first pair of legs simple or subchelate, the second to fourth pairs of legs with the last article curved and flattened, the rostrum small or wanting and the third maxillipeds without mastigobranchs.

Both of the families recognized in this tribe are represented in the Beaufort fauna.

Family ALBUNEIDAE.

Hippidea having the first pair of legs subchelate, the third maxillipeds narrow, and the carapace flattened and without wings which cover the legs.

Of the 4 genera assigned to this family, 2 occur in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Eyestalks narrow, triangular .... *Albunea.*
aa. Eyestalks broad, oval .... *Lepidopa.*

Genus ALBUNEA Weber.

Albunea Weber, 1795, p. 94; Fabricius, 1798, p. 372.

Albunea gibbesii Stimpson. Pl. XXX, fig. 11.

Albunea symnista Gibbes, 1850, p. 187 (not *A. symnista* Fabricius.).
Albunea gibbesii Stimpson, 1859, p. 78; Benedict, 1901, p. 139.

Carapace lyrate, convex from side to side, almost straight along median line; front with a minute rostrum with a strong spine on either side followed by about nine slender spines; anterolateral angle with a stout conical spine which projects little if any beyond the anterior border; posterior margin deeply and broadly notched; dorsal surface with numerous, irregular, impressed lines which take a more or less transverse course, a short one near the front and one crossing near the middle like an inverted *W* being the most conspicuous. Eyes minute, at the tip of the narrow, triangular eyestalks. Antennules about twice as long as carapace, slender and densely ciliated above and below along inner surface. Basal segment of antenna with an acute small spine, flagellum about half as long as peduncle. First pair of legs stout, hairy, all but the distal segments inflated; hand subchelate, the inferior distal angle of propodus produced into a spine, dactyli curved and rather slender. Second, third, and fourth legs stout, hairy, and with falcate dactyli. Fifth legs weak, borne above the others. Second, third, and fourth abdominal segments with expanded pleura. Fifth and sixth segments small. Uropods consisting of a rather large basal article and two small falcate blades. Telson of male triangular, of the female rounded.

Length of a male, rostrum to tip of telson, 36 mm.; carapace, 20 mm.

Color, a light purple with whitish markings, more or less iridescent.

This species, whose distribution extends from North Carolina to the West Indies, is not uncommon on the sandy shoals about Beaufort. It is seldom taken, however, except at times of extreme low tide, when the sand flats are exposed to the heat of the sun and the animal comes to the surface. In the dredging about the fishing banks it has been collected on several occasions, and once it was found in the stomach of a blackfish.

Genus LEPIDOPA Stimpson.

Lepidopa Stimpson, 1858–1860, p. 230 (1858).

Lepidopa websteri Benedict. Pl. XXX, fig. 12.

? *Lepidopa venusta* and *L. scutellata* Kingsley, 1880a, p. 410.
Lepidopa websteri Benedict, 1903, p. 892.

Carapace lyrate, widest anteriorly, sides sinuous and slightly convergent posteriorly. Posterior margin slightly concave; sides of carapace folded inward ventrally, over the bases of the legs, this flap, especially posteriorly, more or less membranous; anterolateral angle produced into a flat spine; front fringed with setæ and produced into a short, triangular rostrum and a slightly more prominent, triangular tooth on either side of it; dorsal surface crossed near the front by an impressed, ciliate band with backwardly directed ends, a narrower band ending in obliquely directed impressed lines crosses at about the middle of the carapace.

Eyestalks oval, lamellate. Antennulary peduncle exceeding eyestalk; flagellum straight, slender, nearly three times as long as the carapace. Antennæ situated at the extreme outer angles of the front; basal article stout; scale reduced to a minute point; flagellum stout, curved, composed of seven short articles. First pair of legs with broad, flat articles, dactyli turned back on propodus to form a subchela. Second, third, and fourth legs without dactyli but with the propodus developed into a halberd-shaped two-pointed foot. Fifth legs much reduced, slender and doubled up between the abdomen and body.

Abdomen short and partly flexed beneath the body; second, third, and fourth segments with expanded pleura. Uropods small, with slender basal article and long oval blades; their margins and those of the abdominal segments fringed with long, silky hairs. Telson lozenge-shaped with rounded corners.

Length of carapace, 12 mm.; width, 15.5 mm.

Color, in alcohol, probably also in life, pure white, but everywhere beautifully iridescent, giving pearly reflections at every turn of the body.

The museum of the Beaufort laboratory contains a single damaged specimen of this animal, the locality of which has been lost, but which undoubtedly came from one of the sea beaches of the region. The only other known specimen, in the collection of Union College, was picked up on the shore near Fort Macon. During the summers of 1911 and 1912 exuviæ of rather small individuals were not at all uncommon along the beach to the west of the fort, where they have been cast up by the waves.

From its similarity to *Albunea gibbesii* and *Emerita talpoida*, this crustacean must be regarded as a burrower in the sand. It has been suggested by Dr. Benedict that its habitat is probably in deeper water than the species mentioned. It must be said, however, that a vast amount of digging close to the shore has failed to produce any living specimen, nor has dredging at distances from the shore varying from 200 yards to 20 miles. The creature may be very local in distribution or may live within the region of tumbling surf where collecting is impossible.

Kingsley lists *L. venusta* and *L. scutellata* as members of the Beaufort fauna, but neither of these is believed to occur in the region. Kingsley's record was unquestionably based on the specimen collected by Prof. Webster, and this is the one which later became the type of Benedict's *L. websteri.* The differences between *L. websteri* and *L. venusta* are very slight, however, and future investigation may show the two species to be identical.

Family HIPPIDAE.

Hippidea having the first legs simple, the third maxillipeds broad, and the carapace subcylindrical and with wings which cover the legs.

This family comprises 2 genera, of which 1 is represented in the Beaufort fauna.

Genus EMERITA Gronovius.

Emerita Gronovius, 1764, p. 234.

Emerita talpoida (Say). Sand bug. Pl. xxx, fig. 8.

Hippa talpoida Say, 1817, p. 160; Coues, 1871, p. 124; Kingsley, 1878–79, p. 326; Paulmier, 1905, p. 135.
Emerita talpoida Benedict, 1901, p. 138; Sumner, 1911, p. 666; Fowler, 1912, p. 366.

Body convex, oval, covered with a firm shell. Carapace imbricately rugose anteriorly, smooth and polished posteriorly; anterior margin with a small blunt rostrum separated by a rounded sinus on each side from a more prominent and acute tooth; an impressed transverse line a little behind the rostrum and a deeper, more strongly curved one farther back; posterolateral margins extending downward to cover bases of legs; anterolateral margins concave and subserrate.

Eyes minute on long, slender stalks. Antennules about twice as long as eyestalks, their basal article with a strong external spine. Antennæ, when extended, nearly as long as cephalothorax; their first peduncular article very short, the second one the largest and with its outer margin produced into a strong, forwardly directed spine, bifid at the tip and with a deep fissure below it; flagellum densely ciliated along the ventral side and normally held concealed within the buccal cavity. First pair of legs directed forward, their articles more or less ciliated and with impressed, interrupted transverse ciliated lines; fifth article spinose at distal end. Second, third, and fourth legs strong, ciliated, their tips curved and foliaceous. Fifth pair of legs almost filamentous, entirely concealed beneath the abdomen.

Abdomen flexed so that the telson and sixth segment lie beneath the body, the uropods being turned forward so as to rest along the sides of the proximal segments. Telson elongate, lanceolate, margined, with reflected cilia above and inflected ones on the edge, base with two short, impressed lines.

Length, 31 mm.; carapace, 15 mm.; telson, 10 mm. Width, carapace, 11 mm.; telson, 5 mm.

This active little crustacean has been collected at various points about the harbor and is to be looked for wherever the beach is composed of clean, fine sand. The outer beach of Bogue Bank is the best collecting ground, however, for there in certain spots it may often be obtained in great numbers. The animals lie in the sand at the edge of the water. As the tide rises or when a large wave washes over them they leave their burrows and scurry to a lower or higher level where they instantly bury themselves only to emerge in a few seconds to seek a new place. In quiet water they lie motionless with only the eyes and antennules above the surface of the sand.[a] A full account of the early stages of this species is given by S. I. Smith,[b] who obtained his material at Woods Hole, Mass.

Section BRACHYURA.

Reptantia having the abdomen much reduced in size, closely bent under the thorax, never used for swimming, and with the appendages of the sixth segment missing; the cephalothorax depressed, the carapace fused with the epistome at the sides and nearly always also in the middle, the antennal scale never movable, the third maxillipeds broad, the first pair of legs chelate and nearly always much stronger than any of the others.

The 3 tribes into which this section is divided are all represented in the Beaufort fauna.

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[a] For an account of the habits of the closely related species *E. analoga*, see Weymouth and Richardson, Smithsonian Miscellaneous Collections, vol. LIX, p. 1–14, 1912.

[b] Transactions of the Connecticut Academy of Sciences, vol. III, p. 311–342, pl. XLV–XLVIII, 1877.

Tribe DROMIACEA.

Brachyura having the buccal frame roughly quadrate, the last pair of legs abnormal in form or size and dorsal in position, the female openings coxal, the first pair of abdominal appendages present in the female, and the gills usually many.

This tribe comprises 5 families, of which 3 are represented in the Beaufort fauna.

Family DROMIIDAE.

Dromiacea having the carapace usually not longer than broad and with a well-marked side edge, the eyes usually completely sheltered by orbits when retracted, the gills 14 to 20 on each side, the sternum of the female with longitudinal grooves, and the fourth and fifth legs small, subdorsal, and usually prehensile.

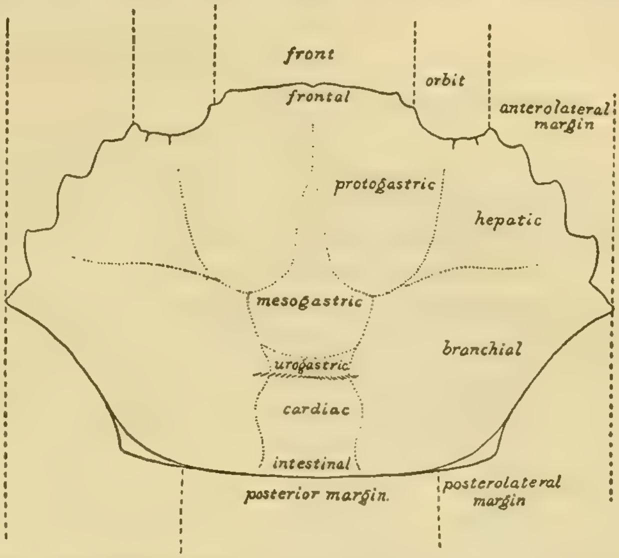
front
frontal
orbit
anterolateral margin
protogastric
hepatic
mesogastric
branchial
urogastric
cardiac
intestinal
posterior margin.
posterolateral margin

FIG. 17.—Dorsal surface of a crab's carapace showing the important regions and margins.

Of the 11 genera assigned to this family 2 have representatives in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Carapace firm and hard; body covered with short hairs . . . . *Dromidia*.
aa. Carapace soft and membranous; body mostly naked . . . . *Hypoconcha*.

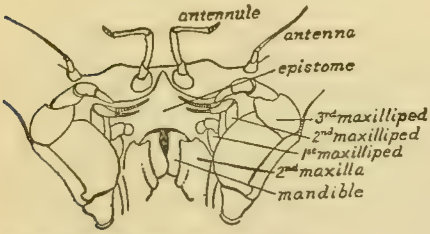
antennule
antenna
epistome
3rd maxilliped
2nd maxilliped
1st maxilliped
2nd maxilla
mandible

FIG. 18.—Mouth region of a crab showing the appendages.

Genus DROMIDIA Stimpson.

Stimpson, 1858-1860, p. 225.

Dromidia antillensis Stimpson. Pl. XXXI, fig. 5.

Dromidia antillensis Stimpson, 1859, p. 24; Benedict, 1901, p. 132; Verrill, 1908, p. 431.

Body and legs covered with a thick coat of short bristles, leaving only the tips of the fingers exposed. Carapace convex in all directions, longer than wide; rostral tooth smaller and on a lower level than the inner orbita teeth; a tooth at about the middle of the superior margin of the orbit and another on the inferior margin; anterolateral margins with four or five dentiform tubercles on each side.

Chelipeds thick and heavy; hand with three blunt spines on upper margin; fingers curved and with strong, interlocking teeth. Second and third legs strong and with long, curved dactyli; fourth and fifth legs subchelate, the fourth pair the smaller and the fifth turned forward onto the back.

Length of carapace of a male, 32 mm.; width, 31 mm.

Color, brownish red, fingers crimson, claws of legs horn color.

Two or three specimens of this curious crab were dredged at depths of about 7 fathoms on the fishing grounds. Like many other crustaceans of the offshore banks it is a West Indian species which has extended its range far northward in this favorable locality. The creature is said to conceal itself by holding a flat or concave piece of living sponge upon its back, but in none of the Beaufort specimens was the habit observed. One perfect specimen brought up in the dredge was clinging to the branches of a *Gorgonia*. It was carried alive to the laboratory, where it was kept for several days in a small aquarium. It spent the entire time huddled up in a corner and showed no interest in anything except some fragments of oyster which were thrown in for it to eat.

Genus HYPOCONCHA Guérin Méneville.

Hypoconcha Guérin Méneville, 1854, p. 333.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Anterior margin of carapace without spines .... *arcuata.*
aa. Anterior margin of carapace with several strong spines .... *sabulosa.*

Hypoconcha arcuata Stimpson. Pl. XXXI, fig. 2.

Hypoconcha arcuata Stimpson, 1859, p. 72; Benedict, 1901, p. 133.

Body short, broad, flattened; dorsally with a thin, parchmentlike covering, ventrally solid and roughly granulate, the appendages capable of being folded compactly against the body. Front margin of carapace nearly semicircular in outline; the margin densely ciliated, deeply fissured in the middle, and with a shallow notch on each side near the middle; ventral surface without ridges, sloping evenly to the anterior margin, and with eyes, antennules, antennæ, and mouth parts deeply seated in depressions in its surface; a narrow fissure in front of the eye, for the lodgment of the flagellum of the antennary flagellum; outer posterior margin of orbit fissured. Third maxillipeds completely closing the buccal cavity. Legs all stout, hairy, and coarsely granulate; the first pair chelate, the fingers somewhat spatulate and toothed at the tip, the thumb set on at an angle with the hand; second and third legs with sharp, corneous tips; fourth and fifth legs borne on the dorsal surface, their penultimate segment very short, and the terminal segment reduced to a little curved claw. Abdomen short, flexed so that its last two segments lie on the thoracic sterna.

Length of a male, in natural position, 33 mm.; carapace, 24 mm.; width of carapace, 24 mm.

Color, gray.

This curious little crab has so far been obtained only in the dredge in Bogue Sound, off Morehead City. It is always found occupying a valve of some lamellibranch shell, preferably, it seems, a clam shell, which it carries about upon its back, after the manner of a hermit crab. By means of the claws on its fourth and fifth pairs of legs, aided, perhaps, by the pressure of its body against the shell, it clings so tightly that it is almost impossible to remove the live animal from its abode without crushing it.

Hypoconcha sabulosa (Herbst). Pl. XXXI, fig. 3.

Cancer sabulosus Herbst, 1799, vol. II, p. 57.
Hypoconcha sabulosa Guérin Méneville, 1854, p. 333; Stimpson, 1858, p. 226; ibid., 1859, p. 72; Benedict, 1901, p. 133.

In form and general appearance very similar to *H. arcuata*, but with the ventral surface nodulose as well as granulate, and marked by several strong ridges. The anterior margin of the carapace is not so deeply fissured, the notches above the antennæ are scarcely evident, and toward the middle, beneath the fringe of setæ, there are several strong spines. The antennary fossæ are limited in front by a pair of strong, oblique ridges, which arise between two of the spines of the anterior border, meeting each other in the middle line at the front of the epistome. The posterior border of the epistome is raised into a prominent ridge, which is continued on either side across the front and some distance along the sides of the buccal area. The basal articles of the antennæ are tuberculate; the basal one has a strong, inwardly directed tooth and the terminal one a tooth on each side of the base of the flagellum. The fissure in the outer margin of the orbit is very noticeable, owing to the development of a strong tubercle on either side of it, the one lying just behind the eye being especially strong and spiniform. The carpal segment of the first pair of legs bears several dentate tubercles.

Length of a female, in natural position, 33 mm.; carapace, 22 mm.; width of carapace, 22 mm.

Color, gray.

This species occurs in Beaufort harbor, but is apparently less common than *H. arcuata*. In habits the two species, so far as is known, are similar.

Family HOMOLIDAE.

Dromiacea having the eyes incompletely sheltered by orbits when retracted, the sternum of the female without longitudinal grooves, the first article of the eyestalk not much longer than the second, and the gills 13 or 14 on each side.

There are 4 genera, of which 1 occurs in the Beaufort region.

Genus HOMOLA Leach.

Homola Leach, 1815, p. 81.

Homola barbata (Fabricius). Pl. XXX, fig. 10.

Cancer barbatus Fabricius, 1793, t. II, p. 460; Herbst, 1796, vol. II, pl. XXXVII, fig. 6.
Homola barbata White, 1847, p. 55; Smith, 1886, p. 637 (33), pl. II, fig. 1.

Carapace about one-fourth longer than wide, its surface everywhere granulate and spinulose and sparsely setose; the sides straight, only slightly convergent posteriorly and extending almost vertically downward from a spiny ridge that extends backward from behind the strong anterolateral spine. Rostrum small, bifurcate at tip. A spine on each side at the base of the rostrum, one at the outer orbital angle, a transverse row of two behind the rostrum, behind these a transverse row of eight, and, a little farther back, a small median spine. Anterolateral parts, below and behind orbits, with small spines.

Eyestalks long, slender at base, and suddenly enlarged below the cornea. Chelipeds of moderate size, their surface granulate and hairy, and the meros and carpus with rows of spines. Walking legs with flattened articles, long, hairy, and spinulose along margins. First segment of abdomen with a prominent median tubercle.

Length of a female: 16 mm.; width, 12.5 mm.

One specimen, a female, was collected by the *Fish Hawk* at station 7334, depth 63 fathoms.

Family LATREILLIDAE.

Dromiacea having the eyes completely exposed on long stalks in which the first article is much longer than the second, the sternum of the female without longitudinal grooves and the gills 8 on each side.

Of the 2 genera, 1 occurs in the Beaufort region.

Genus LATREILLIA Roux.

Latreillia Roux, 1828, p. (1).

Latreillia elegans Roux. Pl. XXXI, fig. 4.

Latreillia elegans Roux, 1828, pt. 5, pl. XXII; Milne-Edwards, 1834–1840, t. I, p. 277; Smith, 1884, p. 351, [7], pl. II, fig. 2–2a pl. III, fig. 1.

Body pyriform, finely granulate, truncate in front and armed with two long, divergent horns between which a minute spinelike rostrum projects obliquely downward; each horn is minutely spinulose near the tip and at about the proximal third bears a spine on the lower side. Front margin of carapace with an acute spine projecting downward at the base of the eyestalks. Abdomen of the female broad; the first segment with a median tubercle; second segment with a strong median spine; third segment, with which the segments which follow are coalesced, with a stout spine on each lateral margin. In the male the abdomen appears to be composed of six distinct segments and lacks all the spines, except the one of the second segment.

Eyes large, pyriform, at the end of slender stalks whose length slightly exceeds that of the supraorbital horns. Third maxillipeds slender and somewhat pediform. Legs very long, almost filiform, their ischial and propodal articles spinulose. Chelipeds about twice as long as the body and about half as long as third walking legs, very slender; hand a little longer than the carpus; movable finger a little less than half as long as the palm.

Measurements of a female: Length, along median line, 9 mm.; width, 5.5 mm.; horn, 5 mm.; third leg, 67 mm.

Three specimens of this bizarre crab, one male and two females, were dredged by the *Fish Hawk* in over 100 fathoms, 30 miles south of Cape Lookout. The species has been reported from the American coast by S. I. Smith whose specimens came from a depth of 70 fathoms off the coast of Massachusetts. It was described by Roux from the Mediterranean.

Tribe OXYSTOMATA.

Brachyura having the buccal frame (endostome) prolonged forward, like a gutter, over the epistome, the female openings usually sternal, the first abdominal appendages of the female wanting, and the gills few.

This tribe includes 4 families of which 3 are represented in the Beaufort fauna.

Family RANINIDAE.

Oxystomata having the body long and more or less abnormal in shape, the abdomen not completely hidden beneath the thorax, the antennæ large and the last two pairs of legs more dorsal than the others and with their last two articles broad.

This family comprises 9 genera of which 1 is represented in the Beaufort fauna.

Genus RANILIA H. Milne-Edwards.

Ranilia H. Milne-Edwards, 1834–1840, t. II, p. 195.

Ranilia muricata H. Milne-Edwards. Pl. XXXI, fig. 1.

Ranilia muricata H. Milne-Edwards, 1834–1840, t. II, p. 195; Kingsley, 1878–79, p. 316.

Carapace oval, strongly convex from side to side, slightly so from front to back, smooth posteriorly but with numerous transverse cilated wrinkles anteriorly; rostrum slender; anterior border of carapace with four strong spines on each side, of which the innermost constitutes the internal angle of the orbit, the third surmounts the external angle of these cavities and the fourth is at the external angle of the front.

Eyestalks strong, about four times as long as the rostrum and capable of being turned back into the deep, oblique orbits. First antennæ very small. Second antennæ directed forward and slightly longer than the eyestalks. First pair of legs subchelate, stout, flattened distally, squamose-denticulate above and with a strong spine on the supero-distal margin of the meros, carpus and manus; distal margin of manus perpendicular, toothed; dactyl strong, curved. Second, third, and fourth pairs of legs with flattened, triangular dactyli. Fifth pair of legs elevated, turned forward and densely fringed with hairs. Abdomen short and narrow.

Color, porcelain white with red vermiculate transverse lines on the cephalothorax and red dots and blotches on the legs.

This species, first credited to the North Carolina fauna by Kingsley, appears to be confined to the sand bottoms well offshore. In the operations on the Blackfish Banks in 1913 and 1914 several specimens were obtained in the dredge and fragments of others were secured from fish stomachs. It has not been met within the harbor nor along the beaches.

Family CALAPPIDAE.

Oxystomata of normal crablike form having the abdomen hidden beneath the thorax, the antennæ small, the legs normal in position, the afferent openings of the gill chambers in front of the chelipeds, the gills nine on each side and the male openings coxal.

This family comprises 11 genera of which 3 are represented in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Posterolateral region of the carapace expanded and dentate .... *Calappa.*
aa. Posterolateral region of the carapace not expanded.
b. Carapace considerably broader than long, regularly convex above .... *Hepatus.*
bb. Carapace nearly as long as broad, dorsal surface very uneven .... *Osachila.*

Genus CALAPPA Weber.

Calappa Weber, 1795, p. 92; Fabricius, 1798, p. 309.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Posterior margin of carapace with only broad and shallow teeth.
  b. Carapace about two-thirds as long as wide; crest of hand eight or nine toothed .... *flammea*.
  bb. Carapace nearly as long as wide; crest of hand six or seven toothed .... *angusta*.
aa. Posterior margin of carapace with a pair of spines near the middle .... *sulcata*.

Calappa flammea (Herbst). Box crabs. Pl. XXXI, fig. 8.

Cancer flammea Herbst, 1796, vol. II, p. 161.
Calappa flammea Bosc, 1802, t. I, p. 185; Miers, 1886, p. 284; Rathbun, 1901, p. 84; Verrill, 1908, p. 420; Summer, 1916, p. 669; Fowler, 1912, p. 116.
Calappa marmorata Latreille, 1803, p. 392; Kingsley, 1878–79, p. 324; ibid, 1880[a], p. 402, (not *C. marmorata* Fabricius).

Carapace about two-thirds as long as wide, convex and granulate above, the granules larger toward the front and grouped to form several longitudinal lines of nodules; front with a broad median notch, projecting slightly beyond the orbits; anterolateral border crenulate, granulate and bluntly dentate; posterolateral margins expanded into winglike extensions and with seven strong teeth with beaded edges; posterior margin arcuate, its edge beaded.

Chelipeds large, capable of being fitted closely against the front of the body; superior margin of carpus and hand raised into a prominent crest which is coarsely granulate on the carpus and eight or nine toothed on the hand; meros with a strong, four-toothed crest parallel with the outer distal border. Walking legs capable of being completely hidden beneath the carapace.

Color buff or light purple with dark purplish-brown lines forming a coarse reticulate pattern over the anterior part of the carapace and thence radiating to the lateral and posterior borders. Carpus with color markings continuous with those of the carapace. Hand light purple with a few dark blotches near the upper part of the outer surface. Inner surface of cheliped largely dark red. Walking legs very light pink.

Measurements of a large male: Length, 86 mm.; width, 132 mm.; length of hand, 73 mm.; width of hand, 58 mm.

This crab, perhaps the most striking one of the region, does not often occur within the harbor, but is not infrequently brought up in the dredge from a depth of a few fathoms outside the inlet. The specimens secured in the harbor are usually less than 25 mm., in width; those obtained outside are usually twice or three times as wide and on rare occasions an individual as large as the one whose measurements are given is captured.

The natural range of the species extends as far northward as Cape Hatteras but in the larval stages it often drifts as far to the north as southern New England. Some of these are supposed to now and then survive a mild winter and to develop by the next summer into the small specimens which have at rare intervals been taken on the coasts of Massachusetts and Rhode Island. The larval stages have been described and figured by S. I. Smith.[a]

Calappa angusta A. Milne-Edwards. Pl. XXXI, fig. 7.

Calappa angusta A. Milne-Edwards, 1880, p. 18.

Carapace about eight-ninths as long as wide, tuberculate and granulate above, the tubercles placed irregularly except in the middle line where there are several in a row; front depressed, deeply grooved in the middle and marked off from the orbits by a groove on each side; anterolateral margin granulate; posterolateral margin with one large tooth at the posterolateral angle in front of which are five or six teeth of diminishing size; on the posterior margin there is one rather strong tooth immediately behind the large tooth at the posterolateral angle and several smaller tubercles and granules.

Chelipeds strong; hand indistinctly tuberculate in rows and with a high crest on the superior margin the edge of which is divided into six or seven teeth; meros with a serrate, transverse crest on the outer surface near the distal end.

Length of a male, 17 mm.; width, 19 mm.

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[a] Trans. Conn. Acad. Arts and Sci. vol. IV, p. 263, 1880.

Color, clear orange red above and on the sides, yellowish behind; tips of the walking legs bright-yellow; chelipeds slightly purplish.

This species had been reported from a depth of 63 fathoms off Cape Lookout and has been taken by the *Fish Hawk* (station 8249) in 47 fathoms at a point about 23 miles off Cape Lookout. In the deeper water of the Gulf Stream it appears to be more abundant, several specimens, one of them a male 32 mm. wide and 28 mm., long, were brought up from depth of from 100 to 200 fathoms.

Calappa sulcata Rathbun. Pl. XXXI, fig. 6.

Calappa sulcata Rathbun, 1898, p. 289; ibid, 1901, p. 85.

Carapace about seven-eights as long as wide, finely granulate and with about 7 rows of tubercles; anterolateral border with about 14 crenulations, granulate on edge; posterior margin between wings with 2 prominent, acute spines; wings not strongly developed, having 6 marginal teeth,2 behind and 3 in front of the posterolateral tooth, which is long and spiniform.

Expansion of meros of cheliped four lobed; superior crest of hand six to seven dentate; outer surface of hand with an irregular, oblique, almost smooth sulcus bordered by tubercles, and an acuminate inferior proximal spine.

Dimensions of a female: Length, 21 mm.; width at sinus just in front of wings, 23 mm.; width at posterior lateral spines, 23.8 mm.

Color, in alcohol, light pinkish brown with a number of small, narrow rings of dark red—3 on the carapace and the others on the chelipeds.

This box crab has been dredged at a depth of 27 fathoms off Cape Lookout, as reported in Dr. Mary J. Rathbun's description of which this is a condensation.

Genus HEPATUS Latreille.

Hepatus Latreille, 1802, t. III, p. 22.

Hepatus epheliticus (Linnæus). Calico crab, Dolly Varden crab. Pl. XXXII, fig. 1.

Cancer epheliticus Linnæus, 1749–69, vol. VI, p. 414; Rathbun, 1897, p. 37.
Cancer decorus Herbst, 1796, vol. II, p. 154.
Hepatus decorus Gibbes, 1850, vol. III, p. 183; Coues, 1871, p. 124; Kingsley, 1880a, p. 324.

Carapace about two-thirds as long as wide, convex above, regularly arcuate in front, and strongly narrowed behind; front narrow, straight, prominent and placed much higher than the continuation of the anterolateral borders of the carapace; anterolateral borders dentate; superior surface of carapace with several transverse lines or groups of tubercles. Chelipeds moderately strong, carpus and manus with lines of coarse tubercles on their outer face and a crest which, on the manus, is four toothed on the superior margin.

Color, dark gray or brownish with numerous, rather large, round or irregular spots of light red with darker borders scattered over the carapace.

This crab is not uncommon in depths of a few fathoms in the channels of the harbor though the individuals so secured are not as numerous nor as large as those taken outside. In a series representing various ages a great deal of variation is to be seen, the granulations being relatively much coarser in the young and the spots more numerous and brightly colored.

Genus OSACHILA Stimpson.

Osachila Stimpson, 1871*b*, p. 154.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Abdomen eroded along the margins and on last two segments.......................... *semilevis*.
aa. Abdomen deeply eroded all over.. *tuberosa*.

Osachila semilevis Rathbun. Pl. XXXI, fig. 9.

Osachila semilevis Rathbun, 1916, p. 652.

Carapace octagonal, with six large protuberances, one mesogastric, one metagastric (paired), one cardiac, one mesobranchial (paired) all of which are rough as if finely eroded, while the depressions are nearly smooth; anterolateral margins continued toward buccal cavity and finely dentate; posterolateral margins thick and with four lobes, the first of which does not project as far as the adjacent anterolateral lobe; the last posterolateral lobe quite prominent; front usually with a narrow buttonholelike sinus.

Cheliped short, thick, tuberculate on the outer face and with rough margins; hand stout; thumb thick; movable finger comparatively slender and straight; upper margin of hand with three simple teeth. Walking legs of moderate size, more or less prismatic and lightly grooved. Abdomen narrow, eroded along the margins and on the last two segments.

Length of a female, 11.6 mm.; width, 13 mm.

Two specimens of this curious little crab were obtained by the *Fish Hawk* (station 7959 and 7978) in about 14 fathoms. The species belongs to the West Indian fauna and hitherto has not been collected north of Florida.

Osachila tuberosa Stimpson. Pl. XXXI, fig. 10.

Osachila tuberosa Stimpson, 1871*b*, p. 154; A. Milne-Edwards, 1880, p. 20 (pt.); Smith, 1886, p. 636 [32]; Rathbun, 1898, p. 118; ibid., 1916, p. 649.

Carapace octagonal with six large protuberances; one mesogastric, one metagastric (paired), one cardiac, one mesobranchial (paired) all of which as well as the lateral margins and, to some extent, the depressions of the shell are eroded; anterolateral margins continued toward the buccal cavity and finely dentate; posterolateral margins with four lobes, the first of which projects sideways slightly beyond the adjacent anterolateral tooth; front usually with a narrow sinus.

Cheliped short, thick, tuberculate on outer face and with rough margins; hand stout; thumb thick, movable finger with a short, dense pubescence; upper margin of hand with three teeth, the proximal one of which is bifid. Walking legs more or less prismatic, with sharp margins and light longitudinal grooves. Abdomen narrow, deeply eroded all over.

Length of female: 18.2 mm.; width, 20.2 mm.,

This species has been recorded by Smith (loc. cit.) from off Cape Hatteras in 48 fathoms. Like *O. semilevis*, it belongs to the West Indian fauna and strays northward along the edge of the Gulf Stream.

Family LEUCOSIIDAE.

Oxystomata of normal crablike form having the abdomen hidden beneath the thorax; the antennæ small, the legs normal in position, the afferent openings of the gill chambers on either side of the mouth at the base of the third maxillipeds, the gills less than 9 on each side and the male openings sternal.

Of the 36 genera now placed in this family 4 have representatives in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Carapace ovoid or globular and smooth or granular.
  b. Fingers opening in a horizontal plane .... *Persephona.*
  bb. Fingers opening in vertical plane .... *Iliacantha.*
aa. Carapace polygonal, uneven, nodular or eroded.
  b. Posterior portion of carapace without deep cavities .... *Lithadia.*
  bb. Posterior portion of carapace with a deep rounded cavity on each side .... *Spelæophorus.*

Genus PERSEPHONA Leach.

Persephona Leach, 1817, p. 18, 22.

Persephona punctata (Linnæus). Purse crabs. Pl. XXXII, fig. 9.

Cancer punctatus Linnæus, 1758, p. 630 (part.).
Guaia punctata H. Milne-Edwards, 1834–1840, t. II, p. 127; Gibbes, 1850, p. 185.
Persephona punctata Stimpson, 1859, p. 70; Coues, 1871, p. 123; Kingsley, 1878–79, p. 324; Rathbun, 1901, p. 87.

Carapace globular, thickly strewn dorsally and laterally with granules of various sizes and with three sharp, recurved spines, one at each end of the posterior margin and one median just above the posterior margin; front narrow, broadly bidentate, produced and elevated and with the dentiform angles of the branchial channels projecting slightly beyond it; anterior and lateral regions bounded externally by a row of beadlike granules which is broken toward the front by a single tubercle of larger size and toward the back extends to a point nearly opposite the end of the posterior margin. Chelipeds subcylindrical in the adult male, about one and a half times as long as the carapace; meros with many large tubercles; carpus and hand nearly smooth except on margins; hand somewhat flattened and dilated; fingers weak.

Color, grayish brown, with darker irregular spots or marmorations, the granules white or tinged with red.

This curious crab is occasionally found stranded at low tide on Bird Shoal, but is more often obtained by dredging in the shallow waters of the region. It is nowhere abundant and so far as is known it is about as likely to be met with in one place as in another. The purselike receptacle formed by the enormously enlarged penultimate segment of the abdomen of the female may be found filled with eggs at almost any time during the summer.

Genus ILIACANTHA Stimpson.

Iliacantha Stimpson, 1871*b*, p. 155.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Fingers about half as long as palm of hand..*intermedia*.
aa. Fingers longer than palm of hand..*subglobosa*.

Iliacantha intermedia Miers. Pl. XXXII, fig. 3.

Iliacantha intermedia Miers, 1886, p. 302, pl. XXVI, fig. 3, 3a.

Carapace orbicular, with upturned and truncate frontal portion; three posterior spines, of which the median is conical, slightly recurved at the tip, and placed at a higher level than the shorter, flattened, triangular spines of the posterior margin; surface of carapace with very small, evenly scattered granules; margins granulate; front deeply grooved above, broadly notched in front and with the spiniform angles of the branchial channels extending beyond it.

Chelipeds slender; the meros cylindrical and granulate, the granules much coarser proximally; manus smooth, nearly as long as carapace, more or less club-shaped, somewhat inflated proximally, but tapering rapidly to the very slender fingers, which are about one-half the length of the palm, incurved at the tip and denticulate on the distal half of their opposable margins.

Color, gray, without markings of any kind; in alcohol, fading to a pinkish white.

Dimensions of a male: Length, 16 mm.; width, 12 mm.; chela, length, 13 mm.; fingers, 4 mm.

Two specimens of this little crab were taken by the *Fish Hawk* at station D 7942. In general appearance it so closely resembles the young of *Persephona punctata* that its identity would be pretty certain to escape unnoticed on a cursory examination.

Iliacantha subglobosa Stimpson. Pl. XXXII, fig. 2.

Iliacantha subglobosa Stimpson, 1871, p. 155.

Very similar to *I. intermedia*, but with less coarsely granulate carapace, more rounded spines at the sides of the posterior end of the carapace and much longer fingers; the latter exceed the palm in length and are armed at regular intervals with relatively large teeth between which are numbers of much smaller teeth.

Length of a male, 21 mm.; width, 16 mm.; chela, length, 22 mm; fingers, 13 mm.

There is no record of the occurrence of this crab in the immediate vicinity of Beaufort, but it has been taken at various points along the coast to the north and south of this locality and doubtless will be found to occur here.

Genus LITHADIA Bell.

Lithadia Bell, 1855, p. 305.

Lithadia cariosa Stimpson. Pl. XXXII, fig. 6.

Lithadia cariosa Stimpson, 1860, p. 238; Kingsley, 1878–79, p. 325.

Carapace convex, subpentagonal, its surface very uneven and covered everywhere, as are the other parts of the body and legs, with beadlike granules, larger posteriorly; front narrow, upturned, and broadly notched; posterior margin bilobate and partly overhung by the large, knoblike cardiac lobe; subhepatic region with a large blunt tooth. Abdomen of male narrow triangular with a backward projecting spine at proximal end of the penultimate segment; abdomen of female with the penultimate segment very large, nearly circular.

Chelipeds stout, a little longer than the width of the carapace, their joints angular, outer margin of manus crested.

Length of carapace, 14 mm., width, 15 mm.

Color, a light gray or buff; the female occasionally with two or three small red spots on the abdomen.

This curious little crab is not uncommon at depths from 1 to 5 fathoms in the channels about Beaufort. When brought to the surface in the dredge it feigns death and is only with difficulty distinguished from the pebbles and bits of shell among which it appears to make its home. Eggs occur at intervals throughout the summer.

Stimpson's material, from which the species was described, came from Beaufort Harbor.

Genus SPELŒOPHORUS A. Milne-Edwards.

Spelæophorus A. Milne-Edwards, 1865, p. 148.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Lateral margins of carapace expanded into broad, flattened wings......................*pontifera.*
aa. Lateral portions of carapace tumid, not expanded into wings............................*nodosus.*

Speloeophorus pontifera (Stimpson). Pl. XXXII, fig. 5.

Lithadia pontifera Stimpson, 1871, p. 115; Rathbun, 1901, p. 88.
Spelæophorus triangulus A. Milne-Edwards, 1880, p. 23.

Carapace subrhomboidal, from one-third to one-sixth wider than long, its surface granulate and very uneven; front narrow, produced, upturned, and with a deep median sinus; orbits small; lateral margin of branchial region on each side extended into a broad wing which conceals the legs and whose outer end is truncate or concave; anterolateral margin concave and with a notch near its middle; posterior margin broad and with a deep rounded cavity on each side of the intestinal region which extends toward, and almost to, a much smaller pit on the dorsal surface at the side of the cardiac region; a narrow suture connects the cavity and pit of each side. From the front a ridge, interrupted at the center of the carapace, extends back along the mid-dorsal line almost to the posterior margin; on each side of this ridge, in the branchial region, is a prominent elevation more or less divided into two parts, one of which is connected by a ridge with the anterior angle of the lateral wing, while the other is similarly connected with the posterior angle.

Chelipeds of moderate size; meros with two large, triangular teeth on the outer margin; fingers slender and curved. Walking legs granulate and tuberculate throughout.

One specimen, 12 mm. wide, was secured by the *Fish Hawk* on the fishing banks.

The species is a small one, apparently attaining a width of about 15 mm., and is extremely variable. The ridges and elevations of the dorsal surface may be sharp and very conspicuous or low and rounded; the angles of the lateral wings of the carapace may be produced or rounded off. The female is not as wide in proportion to her length as is the male, her abdomen is densely tuberculate and the outer posterior part of the lateral wings is somewhat tumid.

Among the specimens in the United States National Museum the extreme of angularity of sculpture in this species is shown by a specimen from off Culebra, P. R. A less angular specimen comes, probably from Florida. The Beaufort specimen is less angular than either of these.

Speloeophorus nodosus (Bell). Pl. XXXII, fig. 4.

Oreophorus nodosus Bell, 1855, p. 307.
Spelæophorus nodosus Milne-Edwards, 1865, p. 149; Rathbun, 1901, p. 89.
Spelæophorus nodosus Stimpson, 1871, p. 119.

Carapace convex, subtriangular or pentagonal, posterolateral angles rounded, its surface evenly and thickly covered everywhere with crowded, rounded granules; a prominent, broad ridge extends backward from the front to the cardiac region; on each side there is a low hump on the hepatic region, and behind this, at the side of the gastric region, there is a much larger hump, and still farther back, near the posterior border, is one of nearly equal size; the posterior humps overhang and largely contain a pair of deep cavities whose rounded mouths open one on each side of the posterior margin. The front is narrow, bilobed, and upturned; a short distance back, on the subhepatic region, is a prominent nodose elevation, and a little farther back two others of slightly smaller size.

Chelipeds short and stout, rough, coarsely granulate and crested along the outer margin; crest of meros with a large distal and a small proximal lobe.

Length of carapace, 15 mm.; width, 17 mm.

Color in life, salmon pink with a few purplish spots on the carapace and rusty brown marks on the legs.

A single adult female of this species was dredged in the channel of Bogue Sound opposite Morehead City on July 14, 1913, and an adult male was taken from a fish's stomach at the Blackfish Bank on August 1, 1914. The species has heretofore been taken much farther south.

Tribe BRACHYGNATHA.

Brachyura having the buccal frame roughly quadrate, the last pair of legs normal in form, rarely reduced in size, and almost never dorsal, the gills few, the first abdominal appendages of the female wanting, and the female openings sternal.

Both of the subtribes and 8 out of the 18 families of this tribe are represented in the Beaufort fauna.

Subtribe BRACHYRHYNCHA.

Brachygnatha having the body oval, circular, or quadrate and broad in front, the rostrum reduced or wanting, and the orbits nearly always well inclosed.

This subtribe comprises 14 families, of which 7 are represented here.

Family PORTUNIDAE. The swimming crabs.

Brachyrhyncha having the body transversely oval, the last pair of legs more or less distinctly adapted for swimming, and the antennæ folding obliquely or transversely.

Of the 33 genera assigned to this family 4 are represented here.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Carapace with five teeth of about equal size on anterolateral margin; interocular teeth three .... *Ovalipes.*
aa. Carapace with nine anterolateral teeth, of which the last is usually much larger than the others; interocular teeth four, six, or eight.
  b. Palate without a longitudinal ridge .... *Arenæus.*
  bb. Palate with a longitudinal ridge.
    c. Abdomen of male triangular .... *Portunus.*
    cc. Last two segments of male abdomen very much narrower than the basal segments.... *Callinectes.*

Genus OVALIPES Rathbun.

Ovalipes Rathbun, 1898, p. 597.
Platyonichus Latreille, 1825, p. 151, pt. (not *Platyonichus* Latreille, 1818, vol. XXVII, p. 4).

Ovalipes ocellatus ocellatus (Herbst). Lady crab. Pl. XXXII, fig. 7.

Cancer ocellatus Herbst, 1782–1804, vol. III, heft 1, p. 61.
Portunus pictus Say, 1817, p. 62.
Platyonichus ocellatus Latreille, 1825, p. 152; H. Milne-Edwards, 1834–1840, t. I, p. 437; Coues, 1871, p. 120; Kingsley, 1878–79, p. 321; Smith, 1886, p. 631; Paulmier, 1905, p. 143; Fowler, 1912, p. 421.
Ovalipes ocellatus Rathbun, 1898, p. 597; Sumner, 1911, p. 672.

Carapace about one-fourth wider than long, convex, finely granulate everywhere except in the median line, where there is a longitudinal band of slightly enlarged granules; front with three acute teeth, of which the median is about twice as long as the lateral ones. Orbit with one shallow fissure above.

Anterolateral teeth strong, acute, directed forward. Inner suborbital angle projecting as far as the median tooth. Lower surface of carapace in the anterolateral region with a curved stridulating ridge. Abdomen of male narrow, its sides nearly parallel; sixth segment more than twice as long as seventh, which is circular; abdomen of female not greatly broader than that of male, widest at fifth segment.

Chelipeds rather large; anterior margin of meros with several small spines and a dense fringe of hairs; carpus with two spines, the inner one very strong; hand triangular, external border costate, internal border with an overhanging densely ciliated ridge, which ends distally in a sharp spine; external costa and internal line of cilia continued onto the dactyl.

Measurements of a male: Carapace, length, 31 mm., width, 38 mm., thickness of body, 12.5 mm.; length of cheliped, 42 mm.

Color, yellowish gray, closely set with small annular spots of reddish purple; carapace and chelipeds with a silvery or brassy iridescence.

The lady crabs are not often observed in the Beaufort region and probably are not as abundant as they are farther north. On Bird Shoal and Shark Shoal and on the ocean beaches their cast-off shells are often to be found, but these are of small size, and would seem to indicate that mostly immature individuals come within reach of the ordinary collector. By the use of the dredge or otter trawl outside the inlet many adult specimens have been obtained, and they appear to be fairly common about the fishing banks. In the spring of 1915 a number of specimens were obtained in the pound net set in Newport River, about 1 mile north of the laboratory.

Ovalipes ocellatus floridanus sub. sp. nov. Pl. XXXII, fig. 8.

Ovalipes ocellatus, var., Smith, 1887, p. 632.
Holotype, No. 47957, U. S. Nat. Mus., ♂ from Pensacola, Fla. Paratypes, No. 17915, U. S. Nat. Mus.

Differs from *Ovalipes ocellatus ocellatus* in the lack of the purple ocellated spots, the color being a uniform grayish yellow; the carapace is less arched and is evenly granulate all over, the median band of enlarged granules not being evident; the anterolateral spines, especially the outer orbitals, are more acute; the orbits are wider, the distance between the outer and inner orbital spines exceeding the distance between the suborbital spines, whereas in *O. ocellatus ocellatus* the reverse is usually true. The broadening of the orbits appears to have been brought about at the expense of the interorbital part of the carapace, the distance between the two inner orbital spines being slightly less than in typical *ocellatus* from the north.

In the region about Beaufort, especially at a distance of a few miles off Cape Lookout, this form of the lady crab is probably much more common than the spotted form. In the harbor it is very rare. Specimens from the neighborhood of Cape Hatteras are not typical in all cases as regards measurements; often the color is the only distinctive character. Along the Florida coast, judging from the collection in the National Museum, the unspotted form is the only one that occurs.

Genus PORTUNUS Weber. The pelagic crabs.

Portunus Weber, 1795, p. 93; Fabricius, 1798, p. 325.

KEY TO THE SPECIES OF THE BEAUFORT REGION.[a]

a. Carapace wide; if the middle of the posterior margin be taken as a center and a circle drawn with the length of the carapace as its radius, the periphery will fall well within the tips of the anterolateral spines .... (Subgenus *Portunus*).
  b. Interocular teeth six, the inner orbital being entire .... *sayi*.
  bb. Interocular teeth eight, the inner orbital being bilobed .... *gibbesii*.

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[a] *Portunus* and *Achelous*.—It is needless, in the present case, to attempt to settle the status of any of the groups into which the genus *Portunus* has been divided. Whether the form of the carapace, the shape and function of the anterior walking legs, the articles of the third maxillipeds, or some other structural detail will furnish entirely satisfactory characters for a division can be determined only by the critical study of a much more extensive collection of species than we have at our command. For the purposes of this paper it appears to be best to follow Dr. Mary J. Rathbun in regarding *Portunus, sensu stricto*, as consisting of those species with a broad carapace and *Achelous* as consisting of those with a narrow carapace, placing both as subgenera under *Portunus*. It is doubtless true that this difference will not show in the case of very young individuals of some of the species, but with reasonably mature and with all adult specimens there should be no trouble in making the distinction.

aa. Carapace narrower; a circle drawn as before will fall well outside the tips of the fifth, sixth, and seventh anterolateral spines..(Subgenus *Acheloüs*).
  b. Interocular teeth eight, the inner orbital being bilobed........................*spinimanus.*
  bb. Interocular teeth six, the inner orbital being entire.
    c. Basal article of last pair of legs with an acute, upright spine..............................*sebæ.*
    cc. Basal article of last pair of legs without an erect spine.
      d. Internal spine of carpus extending to middle of hand or beyond................*spinicarpus.*
      dd. Internal spine of carpus of moderate length.
        e. Superoexternal surface of chela with a conspicuous, smooth silvery or iridescent area. .*ordwayi.*
        ee. Superoexternal surface of chela ridged and not iridescent.
          f. Superior margin of hand with two distal spines, one behind the other; posterior lateral spine distinctly longer than the others....................................*anceps.*
          ff. Superior margin of hand with only one distal spine; posterior lateral spine little if any longer than one in front of it...*depressifrons.*

Portunus gibbesii (Stimpson). Pl. XXXIII, fig. 1.

Lupa gibbesii Stimpson, 1862, p. 57.
Acheloüs gibbesii Stimpson, 1862, p. 222; Verrill, 1908, p. 389.
Portunus gibbesii Rathbun, 1900, p. 140.

Carapace more than twice as wide as long, not tumid, thickly covered with small spherical granules, pubescent, and with three or four naked, transverse ridges, two of which arise from the lateral spines and run toward the gastric region; frontal teeth 8, including the two points of the inner orbitals, each of which is notched at the summit; the 2 median teeth are narrower and slightly more advanced than the next pair; external orbital tooth not much larger than the teeth of the anterolateral border, which are stout, acute, and directed forward; the last tooth, or lateral spine, slender, very sharp, curved forward and about as long as the space occupied by the four preceding teeth; near the anterolateral margin at the base of the teeth are one or more small, naked, iridescent areas.

Chelipeds long, slender; meros with five or six spines in front and one at the distal end; carpus with a large internal and a smaller external spine; chela slender, ribbed on all its surfaces; the ribs continued onto the fingers and made rough by sharp-pointed, appressed tubercles; there are two spines on the hand, one at the articulation with the carpus, the other near the distal end of the superior rib; fingers nearly straight with incurved tips.

Length of a male, 29 mm.; width, 61 mm.

Color, brownish red, the transverse ridges on the carapace and the spines and margins of the chelipeds carmine red.

On the American coast the range of this crab extends as far north as Woods Hole, Mass. It is fairly common about Beaufort and is often taken in the deeper channels of the harbor.

Portunus sayi (Gibbes). Pl. XXXIII, fig. 2.

Portunus pelagicus Bosc, 1805, p. 219.
Lupa pelagica Say, 1817, p. 97; De Kay, 1844, p. 11 (not *L. pelagica* Leach).
Lupa sayi Gibbes, 1850, p. 178.
Neptunus sayi Stimpson, 1860, p. 220.
Portunus sayi Rathbun, 1897, p. 22; ibid, 1898, p. 276; Verrill, 1908, p. 376; Sumner, 1911, p. 672.

Carapace very nearly twice as wide as long, somewhat tumid, smooth and polished to the naked eye, but with a lens it is seen to be finely granulate; frontal teeth 6, including the inner orbitals; the 2 median teeth smaller but on a line with the next pair; external orbital tooth larger than those of the anterolateral border except the ninth, which is stout, acute, and about as long as the space occupied by the three preceding teeth; the teeth of the anterolateral border blunt and increasing slightly in size posteriorly.

Chelipeds of moderate length, somewhat larger in the male than in the female; meros with four, rarely three, stout, curved spines in front, none behind; carpus with two spines. Manus with an acute spine at the articulation and a smaller one near the base of the movable finger; the external surface with two longitudinal ribs of which the lowermost extends onto the finger; the superior surface with three ribs which are continued onto the finger, the innermost one being ciliate beneath.

Length of a male, 20.5 mm.; width, 40 mm.

Color, chocolate brown, with cloudings of olive green and irregular white spots.

A pelagic form, living among *Sargassum*, and not infrequently carried by the currents into the harbor. Quite a number of the specimens taken at Beaufort were egg-bearing.

Portunus (Acheloüs) spinimanus Latreille. Pl. XXXIII, fig. 4.

Portunus spinimanus Latreille, 1819, p. 47.
Acheloüs spinimanus De Haan, 1833, p. 8; Coues, 1871, p. 120; Kingsley, 1878–79, p. 320 (*spinimana*); Verrill, 1908, p. 385.
Lupa spinimana Stimpson, 1859, p. 57.
Portunus (*Acheloüs*) *spinimanus* Rathbun, 1901, p. 45.
Acheloüs smithii Verrill, 1908, p. 386, figs. 32 and 33.

Carapace considerably less than twice as wide as long, finely granulate and pubescent and with a number of prominent, curved, coarsely granulate, transverse ridges; frontal teeth 8, including the inner orbitals, each of which is notched at the summit and presents two points; the 2 middle teeth are slightly narrower and more advanced than the next pair and all are considerably more advanced than the inner orbitals; outer orbital teeth obtuse, not much larger than the teeth of the anterolateral borders which are strong, acute, or acuminate and of about one size except the last, which is about twice as large a, the others and usually curved forward.

Chelipeds long, pubescent, and serratogranulate all over; meros with four, sometimes five, strong, curved spines in front and one at the distal end; carpus with two spines, the inner one much the stronger, and on the upper surface four conspicuous ridges; hand slender, all its surfaces with ridges which extend onto the fingers; a strong spine at the carpal articulation and another near the base of the movable finger; fingers nearly straight, the tips incurved.

Length of a male, 31 mm.; width, 52 mm.

Color, yellowish or reddish brown, ridges of carapace, spines of chelipeds and fingers and tips of legs red, fingers with white blotches.

This species, which bears a general resemblance to *Portunus gibbesii*, is not uncommon in the waters off Beaufort Inlet and is sometimes found in the deeper channels of the harbor. The two species are quite often found in company, as they doubtless require the same conditions, but may be readily distinguished by the narrower, rounder form of *P. spinimanus* and the entire lack of the iridescent patches on the carapace mentioned in the description of *P. gibbesii*.

In his paper on the decapod crustaceans of Bermuda, Verrill has described a subspecies, *smithii*, which he states has been collected at Fort Macon, off Hatteras, and at other points farther south. It has been pointed out by Dr. Mary J. Rathbun [a] that *Acheloüs smithii* Verrill was based upon a misinterpretation of a figure by A. Milne-Edwards [b] of an immature swimming crab said to have come from Chile and identified by Edwards as *Portunus spinimamus*.

It may easily be that the figure in question does not represent *P. spinimanus* of Latreille at all It may even be that Latreille, Leach, and various other early writers confounded two or more species under this name, though this seems unlikely, but the *Lupa*, or *Acheloüs*, *spinimanus* of Stimpson, Smith, Kingsley, and various others was unquestionably the same as the one to which the name is here applied.

Portunus (Acheloüs) spinicarpus Stimpson. Pl. XXXIII, fig. 3.

Acheloüs spinicarpus Stimpson, 1871, p. 148.
Neptunus spinicarpus A. Milne-Edwards, 1879, p. 221.
Portunus (*Acheloüs*) *spinicarpus* Rathbun, 1901, p. 47.

Carapace slightly more than twice as wide as long, sculptured, with a number of naked, rather coarsely granulate, arching, transverse ridges between which the shell is finely granulate and pubescent; frontal teeth 6, including the inner orbitals, the outer margins of which are sinuate but not notched; the true frontal teeth are narrow, acute, separated by broad notches, and the median pair is considerably advanced beyond the others; external orbital tooth acute and larger than the neighboring teeth of the anterolateral margin; the latter vary somewhat in size, are concave sided and very acute, the eighth tooth has the form of a slender, forwardly curving spine more than half as long as the anterolateral border; posterolateral angle sharp, the margin being slightly recurved.

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[a] Proc. U. S. Nat. Mus., vol. XXXVIII, 577 (footnote), 1910.

[b] Arch. Mus. Hist. Nat., Paris, vol. X, pl. 32, 1861.

Chelipeds long and slender; meros with four stout, curved spines in front and a single similar one at the distal end behind; carpus with two spines of which the outer is small and weak while the inner one is very long and extends along the side of the hand almost to the base of the movable finger; hand with serratotuberculate ridges, which are prolonged onto the fingers, and two spines, one at the carpal articulation, the other near the base of the movable finger; fingers nearly straight, incurved at tips.

Length of a male, 18 mm.; width, 38 mm.

Color, brownish yellow with red markings on ridges of carapace, spines of legs and fingers.

This appears to be a species of the deeper waters of the region. It has been dredged from 13 to 134 fathoms off Hatteras, off Cape Fear, and between Hatteras and Cape Lookout, but so far as is definitely known has not been taken anywhere along the shore or in the harbor.

Portunus (Acheloüs) sebæ (Milne-Edwards). Pl. XXXIII, fig. 5.

Lupea sebæ H. Milne-Edwards, 1834–1840, t. 1, p. 455.
Neptunus sebæ A. Milne-Edwards, 1861, p. 329.
Acheloüs sebæ Smith, 1869, p. 34; Verrill; *ibid.*, 1908, p. 380.
Portunus (*Acheloüs*) *sebæ* Rathbun, 1901, p. 46.

Carapace less than twice as wide as long, pubescent and with very indistinct granulate ridges; frontal teeth 6, including the inner orbitals; the outer margins of which are only slightly sinuate; teeth of the median pair blunter and more advanced than those of the next pair; external orbital tooth acuminate and slightly larger than the nearest anterolateral tooth; anterolateral teeth acute or acuminate, their tips turned forward, the eighth one longer than the space occupied by the three preceding teeth.

Chelipeds of moderate length, pubescent and with fringes of silky hairs; meros with five spines in front and one behind; carpus with two spines, the internal one being strong and very sharp; hand with three spines; one at the carpal articulation, a small one immediately above the base of the movable finger, and a larger one farther back; fingers slender, straight. Basal article of last pair of legs with an erect spine.

Length of a male, 29.5 mm.; width, 55.2 mm.

Color, in alcohol, pale brownish yellow, fingers red, a large round red spot on each flank of the carapace. By Verrill the hairs fringing the legs and chelipeds are said to be red.

There is no record of this species having been taken in the Beaufort region, and there are no specimens in the United States National Museum from farther north than Key West, Fla. It occurs in the Bermudas, and both Dr. Mary J. Rathbun and Prof. Verrill state that its range extends from North Carolina to Brazil. The species, in all probability, will be found here sooner or later, and is therefore included in this paper.

Portunus (Acheloüs) depressifrons Stimpson. Pl. XXXIII, fig. 7.

Amphitrite depressifrons Stimpson, 1859, p. 58.
Acheloüs depressifrons Stimpson, 1860, p. 223; Coues, 1873, p. 121; Kingsley, 1878–79, p. 320; Verrill, 1908, p. 391.
Portunus (*Acheloüs*) *depressiforns* Rathbun, 1901, p. 45.

Carapace about one and three-fifths times as wide as long, uneven, pubescent and with indistinct transverse ridges; frontal teeth six, including the inner orbitals, which are neither notched nor sinuate and much larger than the others, the tips of all the teeth about on a line; external orbital tooth strong, its tip rounded; anterolateral teeth acute, turned forward, the eighth scarcely longer than the one in front of it, the teeth and the intervals between them ciliated.

Chelipeds trigonal, serratogranulate and pubescent; meros with five spines in front and a distal one behind; carpus with two spines, the outer much smaller than the inner one; hand short and compressed, its upper margin raised into a crest which terminates distally in a stout spine, a smaller spine at the carpal articulation; fingers flattened, the movable one with a border of cilia on the superior margin. The three pairs of walking legs are unusually long and slender and the first pair has its articles fringed with hairs. The swimming legs are shorter than in most of the species of this genus.

Length of a male, 23.5 mm.; width, 37 mm. (Specimen from Key West, Fla.)

Color: Verrill stated that "in life the carapace is irregularly mottled with light and dark gray, closely imitating the colors of the sand; the chelipeds and posterior legs are similar, though paler; but the first pair of ambulatory legs, which are longer than the others, are bright purple or deep blue, in the larger specimens, while some portion of the same color is usually seen on the next two pairs, but the color of the first pair is in striking contrast with that of the rest of the crab. The very young specimens did not show this distinction in the color of the legs, so far as observed."

This crab, reported from Fort Macon by Coues and by Kingsley has not been collected here for many years, so far as our records go. The United States National Museum has no specimens from farther north than Key West, Fla., and the Bahamas. Prof. Verrill reports it as very common at Bermuda. The original description by Stimpson was based on specimens from the coast of South Carolina and the Florida Keys. It is liable to be found here at any time.

Portunus (**Acheloüs**) **anceps** (Saussure). Pl. xxxiii, fig. 8.

Lupea anceps Saussure, 1858, p. 434.
Acheloüs anceps Stimpson, 1871, p. 113; Smith, 1886, p. 634; Verrill, 1908, p. 378.
Neptunus ventralis A. Milne-Edwards, 1879, p. 215, pl. xl, fig. 3.
Portunus (*Acheloüs*) *anceps* Rathbun, 1900, p. 141.
Portunus ventralis Rathbun, 1901, p. 45.

Carapace twice as wide as long, pubescent and with several distinct arching, granulate, transverse ridges; frontal teeth 6, including the inner orbitals which are blunt and considerably shorter than the outer pair of true frontal teeth; median pair of teeth very short and smaller than the inner orbitals; anterolateral teeth small, acute and curved forward, the last one sharp, slender, and about as long as the space occupied by the four preceding teeth.

Chelipeds long; meros with four spines in front and a distal one behind; carpus ridged and with a strong internal and a smaller external spine; hand with ridges on the outer and superior surfaces, most of which are continued onto the fingers, the superointernal ridge more elevated than the others and ending distally in two spines, one behind the other.

Length of a male, 13 mm.; width, 26 mm. (Verrill).

Color: "Mottled gray and yellowish white so as to imitate the sand pretty closely; the first pair of legs in some were red, in others yellow; the chelipeds and other legs had, in part, the same color." (Verrill.)

The natural habitat of this species is in more tropical waters than those of the Beaufort region, but it, like the other swimming crabs, is carried northward in the Gulf Stream and its occurrence here would occasion no surprise. A good series of specimens was reported by Smith from off Cape Hatteras in 7 to 16 fathoms. Verrill stated that it is not uncommon at Bermuda.

The identity of *P. anceps* and *P. ventralis* was first suspected by Verrill[a] from the comparison of the measurements of Bermudean specimens of *P. anceps* with those given by Dr. Mary J. Rathbun for Porto Rican specimens identified by her as *P. ventralis*. A careful comparison of specimens in the National Museum shows that Prof. Verrill's suspicion was well founded.

Portunus (**Acheloüs**) **ordwayi** (Stimpson). Pl. xxxiii, fig. 6.

Acheloüs ordwayi Stimpson, 1860, p. 224; Smith, 1869, p. 9; ibid., 1870, p. 148; Verrill, 1908, p. 381.
Neptunus ordwayi A. Milne-Edwards, 1879, p. 217.
Portunus (*Acheloüs*) *ordwayi* Rathbun, 1901, p. 46.

Carapace one and one-half times as wide as long, uneven, the elevations granulate and the depressions pubescent, with a number of conspicuous, curving, transverse ridges; frontal teeth 6, including the inner orbitals which are acuminate; true frontal teeth of about one size, triangular, acute, the middle pair advanced beyond the others; outer orbital tooth large; anterolateral teeth diminishing slightly in size from the first to the seventh, inclusive, the eighth about as long as the space occupied by the two preceding teeth, the tips of all acute and turned forward.

Chelipeds of moderate length; meros with four or five strong spines in front and a single distal one behind; carpus ribbed and with a strong internal and a much smaller external spine; hand ribbed on all its surfaces except the superior one, which is flat and highly iridescent over more or less of its area; the superointernal ridge is raised into a crest which terminates distally in a sharp spine. The margins of the carapace and chelipeds are more or less fringed with silky hairs.

Length of a male, 24.5 mm.; width, 37.5 mm.

Color, carapace and legs reddish brown, due to a fine mottling with red, yellowish brown, and gray; beneath pale orange, deeper on the chelipeds and legs; chelæ, above, deep red-brown, the fingers with two cross bands of light orange-red.

Taken by the *Albatross* in 32 fathoms between Cape Hatteras and Cape Lookout.

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[a] Op. cit., p. 379.

Genus CALLINECTES Stimpson.

Callinectes Stimpson, 1860, p. 220.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Frontal teeth, including the inner orbitals, four...*sapidus*.
aa. Frontal teeth, including the inner orbitals, six...*ornatus*.

Callinectes sapidus Rathbun. Blue crabs. Pl. XXXV, fig. 1.

Lupa hastata Say, 1817, p. 65, and 1818, p. 443.
Lupa dicantha De Kay, 1844, p. 10.
Callinectes hastatus Ordway, 1836, p. 568; Coues, 1871, p. 120; Paulmier, 1905, p. 142.
Callinectes sapidus Rathbun, 1896, p. 352; Verrill, 1908, p. 370; Sumner, 1911, p. 672; Fowler, 1912, p. 128–130.

Carapace, including lateral spines, two and a half times as wide as long, moderately convex, nearly smooth except on inner branchial and cardiac regions where it is lightly tuberculate; a tuberculate transverse line from one lateral spine to the other and a shorter transverse line about halfway between this and the frontal margin; frontal teeth, four, including the inner orbitals, triangular, acute, both pairs more or less distinctly bilobed; anterior eight anterolateral spines of subequal length, concave on both margins and acuminate; lateral spines nearly straight, longer than the space occupied by the three preceding teeth; inner suborbital tooth prominent and acute.

Chelipeds of male large and powerful, those of the female considerably smaller; meros with three spines in front and one small one at the distal end behind; carpus with one spine and one spiniform tubercle on the external surface; manus strong, prominently ribbed and with a strong proximal spine; fingers strong, nearly straight and strongly toothed.

Length of a male, 67 mm.; width, 166 mm.

Color, grayish or bluish green of varying shades and tints relieved by more or less brilliant red on the spines of the carapace and the fingers.

This crab, so abundant along the Atlantic coast from Cape Cod southward, is common enough in the Beaufort region to be of some commercial importance. Throughout the summer soft crabs are caught for local consumption and occasionally a few are shipped away. At Morehead City the business of shipping soft crabs is carried on with regularity, though most, if not the whole, of the supply is obtained from Harkers Island and points still farther to the eastward. Hard crabs are not utilized to any marked degree. Some years ago at one of the oyster canneries in Beaufort an effort was made to establish a crab-canning industry, but it was found that crabs could not be obtained in sufficient numbers at the time they were wanted and the venture failed. With proper apparatus and perhaps some patience in training the fishermen to use it there should be no difficulty in securing quite as many blue crabs in the neighborhood of Beaufort as at any other point along the coast. At present fishing is done only with hand nets in the marshes and creeks.

The development and behavior of the blue crab are extremely interesting, but the study of its life history, while of no little practical improtance, is a matter of much difficulty. Young crabs and some of the older ones may be observed with ease in shallow water near the shore; the older individuals, however, prefer deeper water and can not well be watched. When a number are confined together in a limited space they will fight to the death and the victors will devour the vanquished without compunction. To confine a sufficient number of crabs of various sizes and both sexes in separate compartments is troublesome and so far has been an impossibility, except during the summer months. The following brief account is based on the observations of several years, and while incomplete gives the most important facts as far as they have been ascertained.[a] It also indicates how much is still to be learned.

Egg-bearing females begin to appear in the spring, become abundant during the summer, and diminish rapidly in numbers in the early fall. The eggs, when first laid, are of a light orange-yellow color, but as they grow older they darken and finally become dark brown or a dirty gray. They are very small and may number anywhere from 1 to 5,000,000. Collectively they form a mass which projects far beyond the margins of the abdomen of the female and interferes considerably with her movements. She carries them about until they hatch, when the little crabs, in the zoëa stage, leave the mother and float away in the water.

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[a] In this connection see Hay, Report, Bureau of Fisheries, for 1904, p. 397, and Binford, Johns Hopkins Circ. February, 1911; also Chidester, Biol. Bull. xxi, no. 4, p. 235–248, 1911.

The time required by the young crab to pass through the zoëa and megalops stages to the first crab stage is not known, but it is probable that young hatched during the summer complete their transformation before winter. By this time they are about 3 millimeters wide. They probably grow little if at all during the colder months, but early the next spring are ready to begin their active predatory life. If an adequate supply of food is obtained they grow quite rapidly, molting at first at intervals of about a week and later at intervals of about a month, increasing about one-third in width at each molt. By the end of the second summer they have reached a width of from 75 to 100 millimeters.

In both sexes maturity is probably reached in the third or fourth summer after hatching. The full-grown male measures over 160 millimeters from tip to tip of his lateral spines and is about as active and pugnacious an animal as is to be found in the water. The females are somewhat smaller and have weaker chelipeds, but they can inflict a very painful bite and will fight savagely if surprised and retreat is impossible. During the molt at which the female reaches maturity her abdomen loses the triangular shape which it has had through the earlier molts; it becomes broad and rounded and lies loosely on the ventral side of the thoracic sterna. A day or two previous to this molt, under normal conditions, she has been taken up by some male who carries her about until her shell is ready to be cast, guards her during the process, and immediately afterwards mates with her. It is believed that she never mates again, although she may produce more than one lot of eggs, and it is probable that she never molts again. The male also probably does not molt after reaching maturity, but he will mate repeatedly with different females if he has an opportunity to do so.

The courting habit of the male, referred to by Prof. Verrill [a] and others, is very interesting. The "dancing and strutting" is done immediately before the female is taken up to be carried about and does not appear ever to be enacted except before a female that is about to cast her shell. The attitude of the female at such times appears to be one of interest and submission. How soon eggs are produced after mating is not known, but there are reasons for believing that it is not for several weeks and possibly not until the next season. It is not at all likely that two lots of eggs are produced in one summer, although well-developed eggs may be found in the ovary of a female that has just hatched one lot.

Having reached maturity the crab probably lives three or four years. Its enemies, aside from man, do not appear to be numerous and against them it is ordinarily able to defend itself if escape is not practicable. Its shell, however, affords a convenient lodging place for barnacles and bryozoans and its gills and gill chambers become clogged with clusters of a little stalked barnacle (*Octolasma darwini*) all of which doubtless help to weaken it and to make it an easy victim of some hungry fish or a summer storm. Observations made during the summer indicate that the mortality is greatest among the old females at that season of the year, but it may be that the males die and are destroyed in deeper water so that their shells are not cast on the shore. When laden with eggs the females seek comparatively shallow water and at times have been observed in numbers close to the edge of the deep channels which run along the inside of Bogue and Shackleford Banks.

Two specimens of dwarf females, both mature, have been collected at Beaufort. The smaller of these measures only 35 mm. long and 80 mm. wide.

Callinectes ornatus Ordway. Pl. XXXIV, fig. 2.

Callinectes ornatus Ordway, 1863, p. 571; Rathbun, 1895, p. 356; ibid, 1901, p. 48; Verrill, 1908, p. 366.

Carapace of approximately the same proportions as in *C. sapidus;* somewhat tumid and finely granulate throughout. transverse lines distinct; frontal teeth, including the inner orbitals, 6; anterolateral spines shallow and broad, the tips of the first five or six acute, the others acuminate; lateral spines curved forward and hardly as long as the space occupied by the three preceding teeth; inner suborbital angle prominent but hardly acute. First segment of abdomen of male produced laterally into an acute, upturned spine. Chelipeds formed as in *C. sapidus* but with the spines probably more acute, the ridges of the manus more developed and the teeth on the fingers larger and sharper.

Length of a male, 33 mm.; width, 74 mm.

Color, clear grayish or bluish green with red on the fingers and more or less brilliant blue on the front of the chelipeds and terminal joints of the legs, merging into dark blue or purple at the articulations; lateral spines and lower surface of chelipeds and teeth of chelæ ivory white.

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[a] Loc. cit., p. 371, 372.

Callinectes ornatus is by no means rare in Beaufort Harbor though full grown individuals are not to be found. Specimens 3 inches and less in width can usually be collected about Bird Shoal and may easily be distinguished from the commoner *C. sapidus* by their more brilliant coloration and by their greater pugnacity. It also seems that their claws are stronger than those of *C. sapidus* of the same size and their nip is correspondingly more painful.

Genus ARENÆUS Dana.

Arenæus Dana, 1851, p. 130.

Arenæus cribrarius (Lamarck). Pl. XXXIV, fig. 3.

Portunus cribrarius Lamarck, 1818, p. 259.
Lupa maculata Say, 1818, p. 445.
Arenæus cribrarius Dana, 1852, p. 290; Coues, 1871, p. 121; Kingsley, 1878, p. 320; Rathbun, 1901, p. 50; Sumner, 1911, p. 672; Fowler, 1912, p. 413.

Carapace more than twice as wide as long, very finely granulate; produced on each side into a strong spine between which and the orbit are eight strong, somewhat acuminate teeth heavily ciliate beneath; front narrow, not so far advanced as the outer orbital angles, and with three teeth on each side of the median notch; of these teeth the outer one forms the inner angle of the orbit and the central one is partly coalesced with the innermost one; superior wall of orbit with two deep fissures dividing it into three lobes; inferior wall of orbit with a wide external fissue and with the inner angle much advanced; lower surface of carapace hairy.

Chelipeds of moderate size; meros with three spines on the anterior border and a short tuberculiform one near the distal end of the posterior border; carpus with two spines; hand short, with five longitudinal granulose carinæ and two spines, one at the articulation with the carpus and the other above the base of the dactyl. Walking legs rather short and weak, densely ciliate. Swimming feet stout. Basal segment of abdomen produced on each side into a strong, sharp, slightly upcurved spine.

Length of carapace, 27 mm.; width, 59 mm.

Color, light vinaceous brown or olive brown thickly covered over the dorsal surface with small, rounded, white spots; tips of walking legs, yellow.

So far as is known this crab seldom if ever enters the harbor and is rarely washed ashore along the outer beaches. It lives in rather shallow water close to the shore but is sufficiently adroit as a swimmer to escape the dangers of the tumbling surf. The collector in search of specimens should be able to haul a seine or an otter trawl about half a mile offshore and parallel with the beach.

Family CANCRIDAE.

Brachyrnyncna having the body broadly oval or hexagonal, the last pair of legs not adapted for swimming, the first pair of antennæ folding lengthwise, and the second antennæ with short, naked flagella.

This, the typical family of crabs, has been restricted until it now contains but two genera. Of these, one is represented within our limits.

Genus CANCER Linnæus.

Cancer Linnæus, 1758, p. 625; restricted by Leach, 1815, p. 308, 320.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Anterolateral teeth of carapace with denticulate margins................................*borealis*.
aa. Anterolateral teeth with the margins granulate..*irroratus*.

Cancer borealis Stimpson. Northern crab, Jonah crab. Pl. XXXV, fig. 2.

Cancer irroratus Say, 1817 (pt.), p. 60; Gould, 1841, p. 322.
Platycarcinus irroratus Gibbes, 1850, p. 176.
Cancer borealis Stimpson, 1859, p. 50; Kingsley, 1884, p. 317; R. Rathbun, 1884, p. 769; Sumner, 1911, p. 672; Fowler, 1912, p. 133.

Carapace transversely oblong oval, about two-thirds as long as wide, angular at the sides, the surface finely granulate; anterolateral margins divided into nine quadrangular, crenate lobes or teeth, the margins of which are minutely denticulate; front produced beyond internal orbital teeth and with three teeth of which the middle one is longer than the others and depressed; orbits circular, with two narrow fissures above and two below, the suborbital lobe being strongly produced.

Chelipeds about as long as second pair of legs, stout; carpus and hand with strong, granulose rugæ; carpus with a sharp spine at its inner angle; hand smooth on inner face, heavily rugose on outer face; two rugæ continued from hand onto the finger which is slaty black at the tip and somewhat deflexed. Ambulatory legs short, fringed beneath, the dactyli tipped with black.

Length, 62 mm.; width, 91 mm.

Color, yellowish beneath, brick-red above; back with two curved lines of yellowish spots, and behind the middle, a figure somewhat resembling the letter H. The legs are mottled and reticulated with yellow and brick-red and more or less purplish.

Small and immature specimens of this species are sometimes dredged in depths from 3 to 5 fathoms within the harbor. Larger specimens have been obtained in deep water off the coast.

Cancer irroratus Say. Northern rock crab. Pl. XXXV, fig. 1.

Cancer irroratus Say, 1817 [pt.], p. 59; Stimpson, 1859, p. 50; Coues, 1871, p. 120; Kingsley, 1878–79, p. 317; Paulmier, 1905, p. 139; Sumner, 1911, p. 671; Fowler, 1912, p. 429, pl. 134, 135.
Platycarcinus irroratus H. Milne-Edwards, 1834–1840, t. 1, p. 414.
Cancer sayi Gould, 1841, p. 323.
Platycarcinus sayi De Kay, 1844, p. 7.

Carapace about two-thirds as long as wide, convex, granulated; anterolateral border divided into nine teeth whose margins are granulate, not denticulate as in *C. borealis*, and the notches between the teeth are continued onto the carapace as short-closed fissures, giving a pentagonal character to the teeth; posterolateral border a granulated ridge having at its outer end one tooth similar to those of the anterolateral border but smaller; front with three teeth, of which the middle one exceeds the others and is depressed. Abdomen of male broad; first, second, and third segments with a transverse granulated ridge.

Chelipeds of moderate size, not as long as the second pair of legs; carpus with granulated ridges and with a sharp spine at the inner distal angle; hand nearly smooth on inner face, outer face with four or five granulated lines, two of which are continued onto the finger, while the superior one is cristate. Ambulatory legs rather long and slender, meros of first and second pairs extending far beyond carapace.

Length, 65 mm.; width, 95 mm.

Color, yellowish, closely dotted with dark purplish brown, which becomes reddish brown after death.

This crab is rare at Beaufort and the few specimens which have been obtained are immature. At some distance from the coast larger individuals have been dredged up. Both this species and the preceding one are members of a northern fauna, and except in deep water do not extend much farther south than the Carolina coast.

Family XANTHIDAE.

Brachyrhyncha having the body usually transversely oval, the last pair of legs normal, the first pair of antennæ folding obliquely or transversely and the male openings rarely sternal.

This very large family of crabs comprises at the present time 106 genera. Of this number 11 are represented in the Beaufort region.

KEY TO THE GENERA OF THE BEAUFORT REGION.[a]

a. Frontal margin presenting but a single edge, not transversely grooved.
  b. Carapace naked or lightly pubescent, front granulate or smooth, teeth of anterolateral border usually flattened and subtriangular.

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[a] While in most of the keys in this paper it has been possible to utilize generic characters and to show to some extent the accepted ideas of the relationship of the genera, it has been impossible to do so in the case of the family Xanthidæ. The differences between the genera into which the old genus *Panopeus* has been divided are either too subtle to be appreciated, except after long study of the species, or are to be found in a combination of characters no one of which can always be depended upon. It has therefore been necessary to make use of the most trivial characters and, since each genus, with the exception of *Pilumnus*, is represented in the Beaufort fauna by a single species, the key is really a key to the species.

c. Antennæ not excluded from orbits.
d. Teeth of anterolateral margins sharp-pointed.
e. Dactyl of large hand with a large basal tooth.
f. Outer surface of carpus smooth or nearly so .... *Panopeus.*
ff. Outer surface of carpus with a groove parallel with the distal margin .... *Hexapanopeus.*
ee. Dactyl of large hand without a large basal tooth.
f. Fingers of small hand spoon-shaped at their tips .... *Eurypanopeus.*
ff. Fingers of small hand not spoon-shaped at their tips .... *Neopanope.*
dd. Teeth of anterolateral margins blunt-pointed or rounded.
e. Front with two rounded lobes .... *Eurytium.*
cc. Front with two lobulate lobes .... *Menippe.*
cc. Antennæ excluded from the orbits .... *Eriphia.*
bb. Carapace hairy or with extensive pubescent areas, front and anterolateral border with spines or spiniform teeth.
c. Carapace spiny or granulate and with plumose hairs .... *Pilumnus.*
cc. Carapace nodose anteriorly, pubescent posteriorly .... *Lobopilumnus.*
aa. Frontal margin transversely grooved so as to appear double.
b. Carapace more or less nodose in front, fingers black .... *Leptodius.*
bb. Carapace with conspicuous transverse ridges, fingers white or brown .... *Rhithropanopeus.*

Genus HEXAPANOPEUS Rathbun.

Hexapanopeus Rathbun, 1898, p. 273.

Hexapanopeus angustifrons (Benedict and Rathbun). Narrow mud crab. Pl. XXXIV, fig. 7.

Panopeus angustifrons Benedict and Rathbun, 1891, p. 373.
Hexapanopeus angustifrons Rathbun, 1898, p. 273; Sumner, 1911, p. 673.

Carapace about two-thirds as long as wide, convex from front to back, regions fairly well marked, surface finely granulate; anterolateral edge thin and upturned and divided into five teeth, of which the first two are separated by a well-defined sinus, the third and fourth are successively broader and the fifth is shorter, narrower, and more distinctly directed outward; from the fourth and fifth teeth well-defined ridges extend obliquely inward and backward for a distance of about twice the length of the teeth; front narrow and produced, divided by a prominent V-shaped notch into halves, each of which is bilobate, the markedly sinuate anterior border forming a broad inner and a small and inconspicuous outer lobe.

Chelipeds strong, granulate, and finely rugose; meros with a well-developed tooth on the upper margin; carpus with a deep groove parallel to the distal margin, an obtuse tooth at the inner angle, and the superior surface rough and more or less tuberculate; hands unequal and dissimilar; propodus usually with a fairly strong costa above and indications of one on the outer surface; both these costæ are continued onto the fingers, which are strong and inclined to be hooked at their tips; the movable finger of the larger hand has a strong tooth at the base.

Length, 19.5 mm.; width, 28 mm.

Color, variable, sometimes a uniform brownish yellow or even light buff, but usually a dark reddish brown or dark gray, the females usually darker than the males and often more or less spotted. In both sexes the fingers are black or dark brown at the base, lighter at the tips; the dark coloration is not extended onto the hand, but stops abruptly well within the base of the fingers.

This little crab occurs in various parts of the harbor, especially where the bottom is covered with old shells. It is frequently brought up in the dredge in the channel off Morehead City and may be collected in the shallow water about Bird Shoal. It appears to like to hide among the masses of ascidian-covered shells that are so abundant in these localities. In size it ranks far below the common *Panopeus herbstii*, but is rather larger than the other mud crabs of the region. It comes to sexual maturity at a very early age, specimens less than 12 mm. across having been found with eggs.

Genus PANOPEUS Milne-Edwards.

Panopeus H. Milne-Edwards, 1834–1840, t. 1, p. 403.
Eupanopeus Rathbun, 1898, p. 273.

Panopeus herbstii H. Milne-Edwards. Common mud crab. Pl. xxxiv, fig. 9.

Cancer panope Herbst, 1801 (?), p. 40; Say, 1817, p. 58.
Panopeus herbstii H. Milne-Edwards, 1834, t. 1, p. 403; Coues, 1871, p. 120; Kingsley, 1878–79, p. 318; Benedict and Rathbun, 1891, p. 358; Sumner, 1911, p. 673.
Panopeus herbstii var. *obesus* S. I. Smith, 1869, p. 278.
Eupanopeus herbstii Rathbun, 1898, p. 273; ibid., 1901, p. 28; Verrill, 1908, p. 344; Fowler, 1912, p. 122, 123.

Carapace about two-thirds as long as wide, regions well marked, surface sparingly granulate; anterolateral margin with five teeth, of which the first two are coalescent, the third and fourth are larger, prominent, and with arcuate outer margins and acute tips, while the fifth is smaller, acute at the tip and has the outer margin straight; a transverse ridge extends inward from the fifth tooth and a shallow groove from the fourth tooth; front with a narrow median fissure, the anterior margin of each half sinuate.

Chelipeds heavy, finely granulate; carpus without a groove on the superior surface and with a blunt internal spine; hands unequal and dissimilar, the larger one having the movable finger curved and strongly toothed at base, while the finger of the smaller one is more nearly straight.

Measurements of a male: Length of carapace, 26 mm; width, 38 mm.

Color, a dirty gray or slate color; fingers black, the color extending a little onto the palm of the hand.

One of the most abundant crabs of the region, being found wherever the bottom in shallow water is muddy or covered with shells or stones. In suitable localities, along the edges of the higher marshes, it is often found in burrows and frequently associated with *Sesarma reticulata* and *Uca minax*. Specimens from such localities are usually more convex, smoother, have blunter anterolateral teeth, a less conspicuous tooth at the base of the movable finger of the large hand and are more inclined to be of a purplish color than are specimens taken from the channels of the harbor. They probably represent the variety *obesus* Smith, which has been recorded from the Beaufort region by Coues and Kingsley. In their paper on the genus *Panopeus* Dr. Benedict and Dr. Mary J. Rathbun do not recognize the variety *obesus* as a subspecies, but after a careful study of a large number of specimens it was their conclusion that the *obesus* characters, rather than being inherent and transmissable ones, are the result of habitat and habits.

Genus EURYPANOPEUS A. Milne-Edwards.

Eurypanopeus A. Milne-Edwards, 1880, p. 318.

Eurypanopeus depressus (Smith). Flat mud crab. Pl. xxxiv, fig. 4.

Panopeus depressus Smith, 1869, p. 283; Kingsley, 1878–79, p. 319; Benedict and Rathbun, 1891, p. 336; Paulmier, 1905, p. 140; Fowler, 1912, p. 117–118.
Eurypanopeus depressus A. Milne-Edwards, 1880, p. 320; Sumner, 1911, p. 673.

Carapace about three-fourths as long as wide, flattened posteriorly, convex in the anterior half, minutely pubescent and with several fine transverse rugæ; anterolateral teeth three, the first two having coalesced to form a broad lobe whose margin is only slightly sinuate, the remaining teeth acute and thin edged; front nearly straight, median notch small or wanting altogether.

Chelipeds dissimilar and very unequal; the smaller one more rugose than the larger and with the margins of the fingers nearly straight and opposable for a considerable distance while the tips are thin edged and hollowed out—"spoon-shaped"; larger cheliped with nearly smooth articles, the hand very heavy and inflated, movable finger strongly curved, obscurely toothed at the base and meeting the immovable one only at the tip; in the unworn condition both fingers show indication of the spoonlike flattening.

Length of carapace, 14 mm.; width, 19.5 mm.

Color, mottled grayish olive; fingers black, the color of the immovable finger extending well onto the palm.

This species appears to frequent localities where the water is comparatively clean and is not often found where the other mud crabs abound.

Genus NEOPANOPE A. Milne-Edwards.

Neopanope A. Milne-Edwards, 1880, p. 329.

Neopanope texana sayi (Smith). Southern mud crab. Pl. XXXIV, fig. 8.

Panopeus sayi S. I. Smith, 1869, p. 284; ibid, 1874, p. 312, 547; Kingsley, 1878–79, p. 319; Birge, 1883, p. 411–426, pl. XXX–XXXIII; Gissler, 1884, p. 225; Benedict and Rathbun, 1891, p. 363, pl. XXII, fig. 4, and pl. XXIII, fig. 7, 8; Paulmire, 1905, p. 140.
Panopeus texanus Kingsley, 1880a, p. 394; A. Milne-Edwards, 1880 (pt.), p. 312, pl. LVIII, fig. 4.
Panopeus texanus sayi Rathbun, 1898, p. 273.
Neopanope texana sayi Sumner, 1911, p. 673; Fowler, 1912, p. 400, pl. 121.

Carapace about three-fifths as long as wide, quite convex, minutely granulate and lightly pubescent, especially near anterior and lateral regions; anterolateral teeth five, of which the first two are coalesced and separated by only a shallow sinus, the third and fourth are larger and directed forward while the fifth is smaller and directed somewhat outward; from the fourth and fifth teeth short, oblique ridges extend inward and backward; front with a very small median notch, each half only slightly sinuate, the entire effect being that a much flattened curve extending from eye to eye.

Chelipeds smooth, unequal and dissimilar, carpus with a prominent groove parallel with its distal margin; movable finger of large hand without a large basal tooth.

Length, 17 mm., width, 22.5 mm.

Color, usually a dark slaty bluish green, sometimes brown or even buff; fingers black, the color extending well onto the palm.

In the parts of the harbor which support oyster reefs this crab is abundant. It may also be found among the clusters of ascidians on the wharf piling about the town. The zoëa and megalops stages of *P. texanus sayi* have been fully described and figured by E. A. Birge (loc. cit.).

Genus EURYTIUM Stimpson.

Eurytium Stimpson, 1859, p. 56.

Eurytium limosum (Say). Pl. XXXV, fig. 7.

Cancer limosa Say, 1818, p. 446.
Panopeus limosus H. Milne-Edwards, 1834–1840, t. I, p. 404.
Eurytium limosum Stimpson, 1859, p. 56; Kingsley, 1878–79, p. 316; A. Milne-Edwards, 1880, p. 332; Rathbun, 1901, p. 41; Verrill, 1908, p. 358; Fowler, 1912, p. 124.

Carapace about one and one-half times as wide as long, very convex from front to back, nearly plane from side to side, surface smooth to the eye but under a lens finely granulate; front about one-fourth the width of carapace, divided into two lobes by a median notch from which a shallow groove runs back over the gastric region; orbital margins somewhat elevated; external orbital tooth coalesced with the first tooth of the anterolateral border, the division between the two indicated by a shallow sinus; anterolateral teeth with raised margins, the second and third rounded at the tip, the fourth more prominent and subacute.

Chelipeds unequal and dissimilar, more so in the male than in the female; meros with a denticulate superior border and a distal spiniform tooth; carpus not grooved; fingers pointed.

Length of a male, 24 mm., width, 36 mm.

Color in life: "Carapace a brilliant purplish blue; wrist and hand bluish; proximal upper half of movable finger pink; remainder of finger porcelain white; lower portion of chelipeds and also the carpal teeth yellow."[a] The color of the fingers is not continued onto the palm.

This crab is common along the coast farther to the south and is said to have been collected as far north as New Jersey. It is given in Kingsley's list of crustaceans whose range embraces Fort Macon, but is not definitely credited to the Beaufort locality.

So far as is known it has never been taken here, but it is one of the species for which the collector should be on the lookout. It is said to live in holes which it digs along the margins of salt marshes near high-tide level. Its brilliant coloration should enable one to recognize it at once.

Having no Beaufort specimens for study the above description was based on a fine male from Port Royal Island, South Carolina, borrowed from the United States National Museum.

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[a] Rathbun, Bull. U. S. Fish Commission, vol. XX, p. 40.

Genus MENIPPE De Haan.

Menippe De Haan, 1833, p. 4, 21.

Menippe mercenaria (Say). Stone crab. Pl. xxxv, fig. 8.

Cancer mercenaria Say, 1818, p. 448.
Xantho mercenaria H. Milne-Edwards, 1834–1840, t. 1, p. 399.
Pseudocarcinus mercenarius Gibbes, 1850, p. 176.
Menippe mercenaria Stimpson, 1859, p. 53; Coues, 1871, p. 120; Kingsley, 1878–1879, p. 318; A. Milne-Edwards, 1880, p. 262; R. Rathbun, 1893, p. 772.

Carapace transversely oval, about two-thirds as long as wide, convex, minutely punctate and granulate; anterolateral border divided into four lobes of which the first two are wide, the third is wide but dentiform, and the fourth is much narrower and dentiform; front with a median sulcus, on each side of which is a broad trilobulate lobe; orbital border thick, fissures indistinct; antenna not separated from orbit.

Chelipeds very large and heavy, unequal, nearly smooth; inside surface of hands with a patch of very fine, oblique, parallel striæ, fingers each with a large tooth. Ambulatory legs stout, hairy distally.

Measurements of a female: Length of carapace, 79 mm.; width, 116 mm.; length of cheliped, 155 mm.

Color of young specimens, a dark purplish blue, the very young always with a white spot on the wrist. As the animal grows older the color becomes a dark brownish red more or less mottled and spotted with dusky gray.

This crab, which is easily the largest and most massive one of the region, is still relatively abundant, although individuals of the largest size are becoming less and less common. The young are hatched at intervals throughout the spring and summer and, after having assumed the crab form, appear to resort to the deeper channels of the harbor where they live under the shell fragments with which such bottoms are covered. On attaining a width of half an inch or thereabouts they move into shallower water and may be found among the oyster shells and the rocks about the harbor jetties. Here they live until they have attained full size, when, if circumstances seem to demand it, they move to some shoal and just below low-tide mark make burrows. These burrows extend obliquely for a distance of 12 to 20 inches and are about 6 inches in diameter. The largest of these crabs may have an extent between the tips of the chelipeds of over 1 foot, but as they are not inclined to be pugnacious they are easily caught. When discovered in a burrow, it is said that they may be removed with impunity if the collector adopts the simple precaution of keeping his hand to the upper wall of the hole.

As an article of food the stone crab is in great demand and the supply is so meager that even local needs can not be satisfied.

Genus ERIPHIA Latreille.

Eriphia Latreille, 1817, p. 404.

Eriphia gonagra (Fabricius). Calico crab. Pl. xxxv, fig. 6.

Cancer gonagra Fabricius, 1781, p. 505.
Eriphia gonagra H. Milne-Edwards, 1834–40, t. 1, 426; pl. xvi, fig. 16, 17; Rathbun, 1901, p. 42; Verrill, 1908, p. 362.

Carapace about one-fourth wider than long, rather flat, with the regions clearly marked off; nearly smooth posteriorly but granulate anteriorly and with two transverse lines of subspinous granules, one in front of the epigastric lobes and the other across the protogastric and hepatic lobes. Front very wide, strongly deflexed and divided into four lobes, of which the two median are broader and more advanced than the lateral ones and have a finely granulate border; the lateral lobes form the front of the raised margin of the orbits and are in contact beneath with a prolongation of the infraorbital plate, thus completely excluding the antenna from the orbit. Anterolateral margins with a row of five spines including the outer orbital, behind and inside of which are a few squamiform tubercles.

Chelipeds unequal, strong, swollen; hand and carpus with numerous large rounded elevations which are larger on the hands than on the carpi and on the smaller than on the larger hand; movable finger with a squamiform tubercle above at the base and, in the larger hand, a large rounded tooth at the base of the cutting edge. Ambulatory legs rather slender, their distal three segments with fine stiff hairs.

Length of a male, 9 mm.; width, 12 mm.

Color: Most of the anterior half of the carapace and a broad median stripe extending to the posterior margin dark purplish brown, the legs a lighter tint of the same color; front margined with brownish orange; sides of carapace, upper surface of chelipeds, dactyli and bases of legs and a narrow band on the distal margin of the other leg articles light yellow; tubercles of the upper half of the chelipeds dark blue; of the lower half, yellow; lower surface of chelipeds and body white; fingers brown.

Four specimens of this gayly colored crab, all immature males, were collected in August, 1915, from the jetties on Shackleford Bank. They were found under flat rocks while search was being made for *Pachygrapsus transversus* and *Eurypanopeus depressus* but appeared to prefer situations a little higher above the water than the other two species. One individual contained an isopod parasite (probably *Leidya distorta*) in its branchial chamber.

Eriphia gonagra has not been reported heretofore on our coast north of South Carolina. Verrill and others have collected it at Bermuda. It is common from the Florida Keys to Brazil and probably throughout the Bahamas and West Indies.

Genus PILUMNUS Leach.

Pilumnus Leach, 1815, p. 309, 321.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Hand with numerous acute black spines...*sayi.*
aa. Hand without spines...*lacteus.*

Pilumnus sayi Rathbun. Hairy crab. Pl. XXXV, fig. 4.

Cancer aculeatus Say, 1818, p. 449.
Pilumnus aculeatus Guérin-Meneville, 1828; pl. III, fig. 2; H. Milne-Edwards, 1834–1840, t. I, p. 420; Coues, 1871, p. 120.
Pilumnus sayi Rathbun, 1897, p. 15.

Carapace about three-fourths as long as wide, sparsely covered with long filiform and plumose hairs and with about six blackish, acute, nearly erect spines on each side; front depressed, emarginate in the center, obscurely so on each side and with four or five spines on each side; superior and inferior orbital walls with marginal spines.

Superior surfaces of chelipeds and ambulatory legs with many filiform and plumose hairs, the carpal and propodal articles being most thickly covered and having several strong spines as well. Chelipeds large, unequal; carpus with 15 or 20 erect black spines; spines of hand strong and acute above but becoming smaller on the external face; fingers ribbed, black and with obtuse teeth, the movable finger spiny above at base.

Length, 22 mm.; width, 29 mm.

Color, grayish brown irregularly suffused with red; spines mostly black, and the hairs yellow.

This crab which is easily distinguished from all the others in the region, is fairly common on the shelly bottoms of all the channels of the harbor and is not infrequently found crawling about over the wharf piles about the town front. It also occurs rather abundantly on the Blackfish Banks.

Pilumnus lacteus Stimpson. Small hairy crab. Pl. XXXV, fig. 3.

Pilumnus lacteus Stimpson, 1871, p. 142.

Carapace about three-fourths as long as wide and with tufts of plumose hairs on the anterior and scattered single hairs on the posterior parts; anterolateral margins with four anteriorly directed teeth which increase in size from before backwards; front depressed, deeply notched in the middle and with a smaller notch near the eye; orbital margins with small tubercles but without well developed spines.

Chelipeds dissimilar in size but otherwise practically alike, stout, setose and plumose-hairy, and somewhat tuberculate above, but naked and polished below and on the ventral half or two-thirds of both the inner and outer surfaces of the chela; there is a row of small spines on the inner part of the distal margin of the carpus. Ambulatory legs hairy and plumose but without spines.

Length of a male: 11.5 mm.; width, 15.25 mm.

Color, gray or pinkish, the plumose hairs whitish or cream-colored, hands and tips of legs light red.

This species is much rarer at Beaufort than *P. sayi* but may usually be found, if careful search is made, on the wharf piles about the town. It is rarely taken by dredging in the harbor and has only once been found in the material brought in by the *Fish Hawk* from outside.

Genus LOBOPILUMNUS A. Milne-Edwards.

Lobopilumnus A. Milne-Edwards, 1880, p. 297.

Lobopilumnus agassizii (Stimpson). Pl. XXXIV, fig. 5.

Pilumnus agassizii Stimpson, 1871, p. 142.
Lobopilumnus pulchellus A. Milne-Edwards, 1 50, p. 299.
Lobopilumnus agassizii Rathbun, 1898, p. 269.

Carapace convex, strongly nodose and granulate and pubescent everywhere except anteriorly; front consisting of two large lobate masses deeply separated from each other and from the orbits; orbital region with two fissures above and two very narrow ones below, the margin granulate; anterolateral margin with three acute, triangular teeth.

Chelipeds stout and heavy; carpus with forwardly directed granulate tubercles. Ambulatory legs pubescent and hairy, their carpal and propodial articles with minute spines above.

Length, 16 mm.; width, 21 mm.

One female taken by the *Fish Hawk* in 13 fathoms at station 7326 represents this species in the laboratory collection.

Genus LEPTODIUS A. Milne-Edwards.

Leptodius A. Milne-Edwards, 1863, p. 284.

Leptodius agassizii A. Milne-Edwards. Pl. XXXIV, fig. 6.

Leptodius agassizii A. Milne-Edwards, 1880, p. 270, pl. XLIX, fig. 3.

Carapace broad, suboval, flattened and finely granulate posteriorly, conspicuously sculptured anteriorly, the regions lobulate and with coarse granules and fine scattered hairs along the front margin of the lobules; frontal margin double, there being a transverse groove extending across from orbit to orbit, both edges of the groove and the orbital margin granulate; of the five anterolateral teeth, the last two or three only are well developed, sharp and turned forward, the second and sometimes the third are triangular and obtuse and the first (the outer orbital angle) is represented by an elevated mass of granules.

Meros of cheliped slightly surpassing the carapace; carpus strong, with a sharp internal spine and with many irregular, granulate rugæ above; hands unequal, the larger one with strong, blunt-tipped fingers, the smaller one with more slender, more acute and more conspicuously grooved fingers which show a tendency to be spoon-shaped at the tips; in both hands the upper and outer surfaces are granulate and tuberculate, the tubercles being arranged in rows. Walking legs granulate and hairy.

Color, after a short preservation in alcohol, light red, fingers black.

Length of a male, 8 mm.; width, 12 mm.

Three small specimens of this crab were dredged by the *Fish Hawk* in 1915 in 16 fathoms on the fishing banks off Beaufort Inlet. The species has already been collected off Cape Hatteras and at various points farther south. All the Beaufort specimens have the last three anterolateral spines well developed but a series in the United States National Museum from Pensacola, Florida, shows that in larger individuals the number may be reduced to two.

Genus RHITHROPANOPEUS Rathbun.

Rhithropanopeus Rathbun, 1898, p. 273.

Rhithropanopeus harrisii (Gould). Pl. XXXV, fig. 5.

Pilumnus harrisii Gould, 1841, p. 326; De Kay, 1844, p. 7.
Panopeus harrisii S. I. Smith, 1873, p. 547; Kingsley, 1878–79, p. 319; Benedict and Rathbun, 1901, p. 378, pl. XXI, fig. 2, pl. XXIV, fig. 16.
Rhithopanopeus harrisii Rathbun, 1900(b), p. 138; Sumner, 1911, p. 674; Fowler, 1912, p. 397, pl. 119–120.

Carapace about three-fourths as long as wide, much less convex from side to side than from front to back, sparsely pubescent toward the anterolateral angles, protogastric regions with two transverse lines of granules, a similar line from one posterior lateral tooth to the other across the mesogastric region; front almost straight, very slightly notched and with its margin grooved, so that, viewed from in front, it appears to be double; postorbital angle and first anterolateral tooth completely coalesced; the first and second developed teeth of about the same size and perhaps slightly larger than the last one.

Chelipeds quite unequal and dissimilar, carpus not grooved above and with a moderately developed internal tooth; chelæ indistinctly costate above, the larger one with short thumb and strongly curved movable finger, the smaller one with a proportionately longer thumb and long, straight movable finger; in neither hand is there a large basal tooth on the movable finger. Ambulatory legs long, slender, compressed, and more or less hairy.

Length of a male, 14.5 mm.; width, 18.5 mm.

Color, in alcohol, yellowish or brownish, fingers white. In life the color is stated by Fowler to be more or less dull brownish, paler below; chelipeds brownish above, paler below; fingers brownish, not contrasted with rest of propodus. Ambulatory legs all brownish, paler below.

This small crab, which has been collected at various places along the Atlantic coast from Long Island Sound to Florida, has, as yet, not been detected in the Beaufort region. It may be that conditions here are unfavorable for its existence, but it is far more probable that a careful search will bring it to light. It does not appear to be abundant anywhere, but it has been found under a great variety of conditions and has been recorded from fresh-water streams as well as from the brackish and salt water. The description given above has been based on a series of specimens from Indian River, Fla., in the United States National Museum.

Family GONOPLACIDAE.

Brachyrhyncha closely resembling the Xanthidæ but having the body usually square or squarish and the male openings sternal or, if coxal, passing along a groove in the sternum.

Forty-nine genera are now assigned to this family, only one of which is represented within the Beaufort limits.

Genus EURYPLAX Stimpson.

Euryplax Stimpson, 1860, p. 60.

Euryplax nitida Stimpson. Pl. XXXVI, fig. 8.

Euryplax nitidus Stimpson, 1859, p. 60; Smith, 1870, p. 162.
Euryplax nitida Stimpson, 1871, p. 150; Kingsley, 1880a, p. 399; Rathbun, 1901, p. 8.

Carapace about two-thirds as long as wide, convex from front to back, less so from side to side, surface smooth and shining; anterolateral margin short and armed with three stout teeth including the outer orbital angle; front about half as broad as carapace, entire or very faintly notched in the middle, deeply notched on each side above the antennæ, orbits wide.

Chelipeds stout; distal end of inner face of meros of male with a round or oval pit concealed by a tuft of plumose hairs; carpus broad, inner margin with a sharp spine and below this a pilose patch. Walking legs slender. Females with narrower carapace, no pit at the end of the meros and the chelipeds more nearly equal.

Length of a male, 6.5 mm.; width, 10.5 mm.

Two specimens were taken by the *Fish Hawk* at depths of 14½ and 16 fathoms on the fishing banks. Both are males and of small size. Another specimen in the laboratory, probably from the same locality in 1902 or 1907, is a female of a larger size but badly broken.

Family PINNOTHERIDAE. The commensal crabs.

Small commensal Brachyrhyncha having the body more or less globose or quadrate, the carapace often more or less membranous, and the eyes and orbits very small.

This family comprises 23 genera, of which 3 have representatives within the Beaufort limits.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Dactyli of the walking legs simple, acute.
  b. Third walking leg little, if any, longer than the other legs.
    c. Carapace globose and more or less membranous; buccal mass subquadrangular.....*Pinnotheres*.
    cc. Carapace more flattened, oval, and rather firm; buccal mass subtriangular......*Parapinnixa*.
  bb. Third walking leg longer and stronger than the others, often considerably so.............*Pinnixa*.
aa. Dactyli of the first, second, and third walking legs bifurcate.........................*Dissodactylus*.

Genus PINNOTHERES Latreille.

Pinnotheres Latreille, 1802, p. 25.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Carapace nearly naked; second pair of legs stouter than third pair.......................*ostreum.*
aa. Carapace covered with a short pubescence; second pair of legs not stouter than third pair. .*maculatus.*

Pinnotheres ostreum Say. Oyster crab. Pl. XXXV, fig 9.

Pinnotheres ostreum Say, 1817, p. 67; De Kay, 1843, p. 12; Stimpson, 1859, p. 67; Smith, 1873, p. 367; R. Rathbun, 1884, p. 765; Paulmier, 1905, p. 149; Sumner, 1911, p. 674; Fowler, 1912, p. 138.

Carapace of female subcircular in outline, tumid, membranous, smooth, and with a broad, shallow, longitudinal depression at each side of the cardiac and gastric areas; front rounded, slightly produced, covering and concealing the eyes. Abdomen very large and broad, extending forward to the mouth parts and laterally to or beyond the bases of the legs.

Eyes, antennules, and antennæ greatly reduced. Chelipeds small, the articles subcylindrical and polished; hand weak, its superior margin elevated above base of movable finger; fingers short, the immovable one conical and pubescent on its inner surface, movable one slenderer and curved. Second pair of legs slender but stouter than the others and with the penultimate article swollen; third pair longest, fifth pair turned backward and upward.

Measurements of a female: Length of carapace, 9 mm.; width, 11 mm.; length of hand, 4.5 mm.

Color: Female, in life, whitish or salmon pink.

This well-known commensal of the oyster has been collected in various parts of the Beaufort region, and doubtless is distributed generally throughout the area. It is females alone, however, which are abundant; no specimen of the male has yet been obtained at Beaufort. In the National Museum, among more than a hundred females, collected at many localities and at various seasons, Dr. Mary J. Rathbun has found but a single very small and immature male. By S. I. Smith the male of *P. ostreum* is said to be free swimming. The scarcity of the sex in collections indicates that this may be true, but it is also possible that Smith mistook the unspotted form of the next species for the male of *P. ostreum.*

Pinnotheres maculatus Say. Pinna crab, mussel crab. Pl. XXXV, fig. 10.

Pinnotheres maculatum Say, 1818, p. 450.
Pinnotheres maculatus Stimpson, 1859, p. 67; Coues, 1871, p. 123; Kingsley, 1878–79, p. 323; R. Rathbun, 1884, p. 766; Sumner, 1911, p. 674; Fowler, 1912, p. 136–137.
Pinnotheres ostreum Smith, 1873, pl. I, fig. 2.

Carapace of female semimembranous, suborbicular, somewhat narrowing anteriorly, the sides being obliquely truncated; median regions defined by deep, irregular sulci; surface covered with a dense but very short pubescence; front bilobate. Abdomen very large, as in *P. ostreum.*

Cheliped moderately stout, its articles subcylindrical and more or less pubescent; hand well developed, its palmar portion about twice as long as the fingers, both of which are nearly straight, hooked at their tips and toothed. Walking legs slender, with short curved dactyli, none of them conspicuously larger than the others, the penultimate article of the second pair not swollen; last pair smallest and turned forward and upward and with longer dactyli than those of the other legs.

The males differ from the females in being much smaller, firmer in texture, and flatter; the chelipeds are shorter and stouter and the second and third pairs of walking legs have the carpal and propodial articles densely fringed with silky hairs.

Measurements of a female: Length of carapace, 16 mm.; width, 17.25 mm.; length of hand, 9 mm.

Measurements of a male: Length of carapace, 8.4 mm.; width, 7 mm.; length of hand, 3.5 mm.

In this crab there are two distinct color phases—one is a plain, almost uniform yellowish-brown, the other has the carapace black or dark brown with a central dorsal stripe and two symmetrical spots of white, while the sternum and abdomen are white with narrow bars of black. Heretofore the uniformly colored individuals have been regarded as females and the spotted ones as males, but a recent examination by Dr. Mary J. Rathbun, of the specimens in the National Museum, shows that this is not always the case. The males, both young and adult, are usually spotted, but are sometimes plain. The females are usually spotted when young, but are always plain colored when adult.

Dr. Rathbun suggests in explanation of this unusual condition of affairs that the habitat of the individual may determine its coloration. The male of this species, as is well known, can move about and doubtless spends more or less of his life swimming from place to place. The young females may, to some extent, have the same habit, and so long as they are free swimming they may be spotted. But as soon as an individual of either sex settles down to a commensal life with some mollusk, it may lose its spots and become uniformly colored.

The female of *P. maculatus* alone is common. She is frequently found as a commensal in the shells of *Pinna* or of *Pecten* and will probably be found to occur in other lamellibranchs. Occasionally a male will be found in company with a female, more rarely he is found swimming freely in the water.

Genus DISSODACTYLUS Smith.

Dissodactylus, S. I. Smith, 1870, p. 172.
Echinophilus Rathbun, 1900b, p. 590.

Dissodactylus mellitæ (Rathbun). Pl. XXXVI, fig. 1.

Echinophilus mellitæ Rathbun, 1900b, p. 590.
Dissodactylus mellitæ Rathbun, 1901, p. 22; Sumner, 1911, p. 675.

Carapace about 1.25 as wide as long, oval, smooth, and polished except in the anterolateral portions, where there is a slight pubescence. Front slightly emarginate and fringed with short stiff hairs. From the anterolateral angle a low ridge runs obliquely inward and backward about halfway to the median line.

Chelipeds short and stout; chela longer than the other articles combined, cylindrical, its upper and outer faces with a few impressed, short, oblique lines from which short appressed hairs extend distally; fingers considerably shorter than palm, bent inward and curved, their opposable margins with tufts of short bristles; carpus with a distal fringe of short hairs and an impressed line similar to those on the chela; meros very short and stout, its lower surface with oblique lines. Second, third, and fourth legs stout, their margins fringed with short hairs and their dactyls deeply bifid. Fifth legs with styliform dactyls and fringed with long hairs along both front and hind margins.

Length of a male, 3 mm.; width, 3.6 mm.

This minute crab, which, with the exception of *Leucifer*, is probably the smallest of our malacostracan fauna, is fairly abundant throughout the region. It is to be found clinging to the spines of the sand dollar (*Mellita pentapora*), which occurs in great numbers on the shoals and sandy bottoms both within and outside the harbor. In some localities a crab or two will be found on nearly every sand dollar examined, but usually they are not present in such numbers. When the sand dollar is lifted from the water, the crabs scurry about over their host and quickly drop off to hide in the sand.

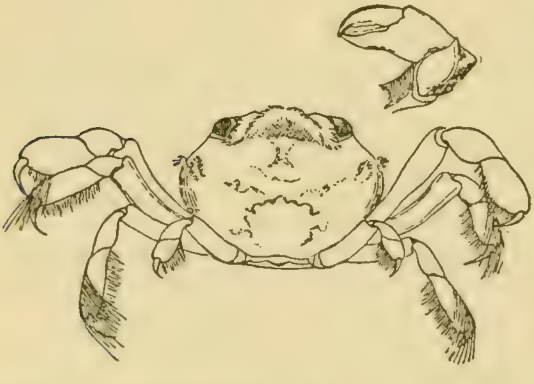

FIG. 19.—*Parapinnixa beaufortensis*, dorsal view. Type, ♂ X20.

Genus PARAPINNIXA Holmes.

Parapinnixa Holmes, 1895, p. 563.

Parapinnixa beaufortensis Rathbun.

Parapinnixa beaufortensis Rathbun, 1918, p. 112.

Carapace rather regularly oval, about one and one-third times as wide as long, with the surface behind the anterior border depressed and plumose; regions indicated by a series of pits which are light brown in the specimen preserved in alcohol. Fronto-orbital width two-thirds as great as width of carapace; front about two-fifths width of carapace, a large emargination at its middle in dorsal view; edge of lobes sinuous. A tuft of hair on either side of dorsal surface near lateral margin, but not projecting sideways beyond that margin. A similar tuft, attached to the ventral surface, projects beyond the margin. Eyes large, of a bronze-brown color.

The outer maxillipeds are characteristic of the genus. Chelipeds stout; carpus squarish in dorsal view, its outer distal angle prominent; palm inflated, margins convex, lower margin hairy, width greater at distal than proximal end, the upper distal angle higher than base of dactylus; dactylus about as long as upper edge of palm; both fingers much curved; when closed the tips cross and there is no gape, the thin and irregularly denticulate edges fitting together.

Legs fringed with long hair, especially on the propodites, where there is a border of hair on the lower margin, and in the second and third legs a row of still longer hair attached near the upper margin on the posterior surface, the length of the hairs being twice as great as the width of the propodite. The legs diminish in stoutness from the first to the fourth. The first leg is a little longer than the second, the third about as long as the first. Propodites stout, upper margins convex. Dactylus of first three legs long, curved, the slender horny tips about half the entire length; dactylus of fourth leg similar in shape, but very much smaller.

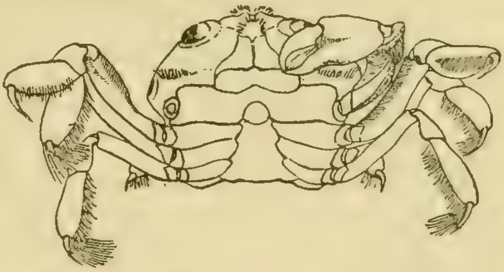

FIG. 20.—*Parapinnixa beaufortensis*, ventral view. Type, ♂ × 20.

Abdomen of male suboblong, distally tapering, at base not more than half the width of the sternum; sutures faint except the one marking the subtriangular terminal segment.

Length of carapace of male, holotype, 1 mm.; width of same, 1.3 mm.

The almost minute specimen upon which this species was established and which, up to the present time, is unique, was detected by Dr. Mary J. Rathbun among some material sent to the United States National Museum from the fishing grounds, 20 miles off Beaufort Inlet. From its small size, relatively large eyes, the long hairs on the legs, and the thin prehensile edges of the fingers, Dr. Rathbun surmises that the specimen may possibly represent a postlarval stage of some crab, the adult of which is as yet unknown.

We are indebted to Dr. Rathbun for permission to copy her description and figure of this specimen. Owing to its small size and the lateness of its discovery it has not been possible to secure a satisfactory photograph for the plates which illustrate this paper.

Genus PINNIXA White.

Pinnixa White, 1846, p. 177.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Chela with the thumb much shorter than the movable finger and bent downward.
  b. Posterior part of carapace with a short transverse ridge more or less interrupted in the middle.
    c. Penultimate article of third pair of walking legs about as broad as long...........*chætopterana.*
    cc. Penultimate article of third pair of walking legs distinctly longer than broad...........*sayana.*
  bb. Posterior part of carapace with a conspicuous transverse ridge extending uninterruptedly from side to side...*cristata.*
aa. Chela with the thumb about as long as the movable finger and not bent downward.....*cylindrica.*

Pinnixa chætopterana Stimpson. Pl. XXXVI, fig. 4.

Pinnixa chætopterana Stimpson, 1860, p. 235; Sumner, 1911, p. 674.
Pinnixa cylindrica Stimpson, 1859, p. 68.

Carapace transversely oval, a little more than twice as wide as long; surface uneven, sides densely pubescent, and the regions well defined by pubescent sulci; cardiac region with an acute transverse crest broadly interrupted in the middle so as to form two dentiform prominences, more conspicuous in the male than in the female; front narrow and with a deep median groove.

Chelipeds stout, pubescent; hand, in the male, with the palmar edge perpendicular, the immovable finger very short, deflected, and with a tooth on its cutting edge, the movable finger strongly curved, smooth on both edges and meeting its fellow only at the tip; hand of female smaller, its palmar edge oblique and the immovable finger considerably longer than in the male. Second and third pairs of legs slender; fourth pair longer and much stouter, conspicuously pubescent and with the inferoposterior margins of the third, fourth, and sixth segments dentate; fifth pair like the fourth, but smaller.

Measurements of a male: Length of carapace, 5.25 mm.; width, 12 mm.; length of hand, 5 mm.

Color, nearly white, but usually much obscured by the brown or blackish hairs and the dirt collected in them.

This crab lives commensally with the worms *Chætopterus pergamentaceus* and *Amphitrite ornata* and is seldom found outside their tubes.[a]

Pinnixa sayana Stimpson. Pl. XXXVI, fig. 3.

Pinnixa sayana Stimpson, 1859, p. 236; Kingsley, 1878–79, p. 323; Sumner, 1911, p. 674.
Pinnixa cylindrica Smith, 1873, p. 546.

Carapace smooth and polished, lightly pubescent on the sides, depressed at the middle, and with a low, ill defined, transverse ridge parallel with and close to the posterior margin extending about one-third the width of the carapace; two similar ridges on the anterolateral slope, distant from but nearly parallel with each other, the superior one curving inward and defining the branchial region; front deeply grooved above.

Hands stout, compressed, hardly twice as long as broad; immovable finger very short; movable finger strongly curved; both fingers toothless. Walking legs smooth, penultimate pair larger than the others, but not so much so as in *P. chætopterana*.

Measurements of a male: Length of carapace, 3 mm.; width, 6 mm.

Color, almost white, but more or less stained with brown.

This crab, the carapace which resembles that of *P. cylindrica*, while its hands are more like those of *P. chætopterana*, is said to be occasionally found in the sand-walled tubes of *Arenicola cristata*. The specimens from which the species was originally described by Stimpson were dredged in 6 fathoms, sandy mud, off the mouth of Beaufort Harbor.

Pinnixa cristata Rathbun. Pl. XXXVI, fig. 5.

Pinnixa cristata Rathbun, 1900, p. 589.

Carapace smooth, polished, and very slightly pubescent at the extreme outer corners, not depressed in the middle and with a conspicuous sharp, almost straight ridge which extends without a break entirely across the shell a little in front of the posterior border; anterolateral ridge less conspicuous.

Chelipeds stout and constructed like those of *C. chætopterana*, but perfectly smooth except for a band of fine hair along the lower margin on the inner surface. Walking legs somewhat longer than those of related species and sparsely hairy along the margins only.

Measurements of a female: Length of carapace, 4.3 mm.; width, 10 mm.

The only known specimen of this species was collected at Beaufort many years ago by Prof. H. E. Webster, of Union College, N. Y., and is now in the United States National Museum. No data accompanied it, so we are uninformed as to its mode of life. It doubtless lives as a commensal in the tube of one of the many species of worms and should be looked for with care. In general appearance it resembles *P. cylindrica*, but has a hand like *P. sayana*. The shell is broader in proportion to the length than in *P. cylindrica*, however, and the legs are markedly more slender. The long, unbroken ridge across the back is a mark that can hardly be overlooked.

Pinnixa cylindrica (Say). Pl. XXXVI, fig. 2.

Pinnotheres cylindricum Say, 1818, p. 452; De Kay, 1844, p. 13.
Pinnixa cylindrica White, 1846, p. 177; Stimpson, 1860, p. 235; Kingsley, 1878–79, p. 324.
Pinnixa lævigata Stimpson, 1859, p. 68.

Carapace smooth, polished, punctate, pubescent at the extreme outer corners, depressed in the middle, a very inconspicuous transverse ridge parallel with and close to the posterior margin, and a more conspicuous anterolateral ridge; front bilobed, but not as deeply grooved as in *P. chætopterana* or *P. sayana*.

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[a] Enders, H. F.: "Notes on the commensals found in the tubes of *Chætopterus pergamentaceus*," Amer. Nat., vol. XXXIX, 1905, p. 37.

Chelipeds moderately stout; hand about one and one-half times as long as wide, fingers gaping at base and of nearly equal length, the immovable one curved upward and with a tooth near its tip; the movable one curved and with a tooth near the middle. Walking legs smooth above and below, pubescent only on the basal articles, the meral and carpal articles more or less crested and fringed with hairs; penultimate pair large and thick.

Measurements of a male: Length of carapace, 5.2 mm.; width, 10.5 mm.; hand, 4 mm.

This species, like the others of the genus, is found most frequently as a commensal in some worm tube. An occasional specimen has been found swimming about in the water.

Family GRAPSIDAE.

Brachyrhyncha having the body more or less distinctly quadrate, the front broad, the eyestalks of moderate length, and a gap of at least appreciable size between the third maxillipeds.

Thirty-nine genera are included in this family. Of these, five are represented in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Antennæ covered by the front.
  b. Third maxillipeds without a pubescent oblique ridge.
    c. Carapace decidedly broader than long. . . . . *Pachygrapsus.*
    cc. Carapace about as long as broad; legs strongly fringed with hairs. . . . . *Planes.*
  bb. Third maxillipeds with an oblique pubescent ridge crossing the ischium and meros. . . . . . . *Sesarma.*
aa. Antennæ visible from above.
  b. Antennules covered by the front; carapace broadest anteriorly. . . . . *Euchirograpsus.*
  bb. Antennules folded back into a pair of deep frontal notches; carapace broadest at about the middle . . . . *Plagusia.*

Genus PACHYGRAPSUS Randall.

Pachygrapsus Randall, 1839, p. 127.

Pachygrapsus transversus Gibbes. Mottled shore crab. Pl. XXXVI, fig. 9.

Pachygrapsus transversus Gibbes, 1850, p. 181; Rathbun, 1901, p. 17.

Carapace rectangular, about one-fourth wider than long, depressed, polished, and finely plicate, the plicæ being transverse except on the branchial regions, where they are oblique. Sides strongly converging posteriorly and with a well-marked tooth behind the orbital angle. Front slightly more than half as wide as carapace, its edge sinuous, and its upper surface with four low elevations.

Chela finely granulate, ridged longitudinally on lower outer surface, margins rounded; dactyl with smooth upper margin. Posterodistal angle of the meros of ambulatory legs and anterodistal angle of meros of chelipeds dentate.

Measurements of a male: Length, 11 mm.; width, 14 mm.

The ground color is almost black, crossed by numerous fine greenish-gray lines which follow the transverse and oblique plicæ and at intervals unite to form spots of various sizes and shapes. The ambulatory legs are dark brown or blackish with gray spots.

This crab appears to occur in this region very irregularly. The first specimen was collected in 1902 from the piles of the railroad wharf at Morehead City. No more were observed until 1912, when it became common on the beaches of Bogue and Shackleford Banks. In 1913 and 1914 it was not collected, but in 1915 and 1916 it was again found in small numbers on the Shackleford jetties. Owing to its close resemblance both in appearance and habits to *Sesarma cinerea* it is apt to be overlooked except by one familiar with it.

Genus PLANES Bowdich.

Planes Bowdich, 1825, p. 15.

Planes minutus (Linnæus). Gulf-weed crab. Pl. XXXVI, fig. 6.

Cancer minutus Linnæus, 1758, p. 625.
Grapsus minutus Latreille, 1803, p. 68.
Planes clypeatus Bowdich, 1825, p. 15.
Nautilograpsus minutus H. Milne-Edwards, 1834–1840, t. II, p. 90; De Kay, 1844, p. 15.
Planes minutus, White, 1847, p. 42; Verrill, 1908, p. 325; Sumner, 1911, p. 675; Fowler, 1912, p. 140–141.

Carapace quadrilateral, as wide as long, depressed, smooth, and with a shallow foveola or longitudinal groove between the orbits; front decurved, usually slightly emarginate in the middle, its edges minutely denticulate or smooth; orbits large; outer orbital angle spiniform and behind it a small sinus.

Eyes large, on stout stalks. Chelipeds large and heavy; chelæ inflated and smooth, the immovable finger bent downward, movable finger curved, both with blunt teeth throughout their length; carpus with a strong spine on inner face; meros and ischium with a thin serrate crest along the inner margin, which terminates at the distal end of the meros in two or three spines. Walking legs with brown, horny dactyls and a few minute denticles.

This little crab is truly pelagic and of world-wide distribution. It is occasionally found along the outer beach and more rarely in the harbor on floating planks and logs covered with goose barnacles. It is of a reddish-fawn color, more or less blotched with dark brown, and usually has a small white spot on each side or a large white spot on the front of the carapace.

Genus EUCHIROGRAPSUS A. Milne-Edwards.

Euchirograpsus A. Milne-Edwards, 1853, p. 175 (141).

Euchirograpsus americanus A. Milne-Edwards. Pl. XXXVI, fig. 7.

Euchirograpsus americanus A. Milne-Edwards, 1880, p. 18.

Carapace flattened, subquadrate, the length and width about equal, the lateral borders nearly straight and parallel; surface finely granulate and with a few very short, fine hairs visible only with a lens; front somewhat produced, lamellate and rather broadly notched. There is a small shoulder at the inner canthus of the orbit. The external orbital angle is spiniform, and behind this, on the margin of the carapace, are three smaller spines, of which the first and third are less developed than the second.

Chelipeds stout; the meros with a dentate crest below; the hand with longitudinal granulate ridges, those of the upper surface with hairs. Ambulatory legs strong, long, and with flattened, spiny meral articles, the dactyli with five or six strong spines, of which the distal three are especially prominent at the tip of the leg.

Length of carapace, 8 mm.; width, 8.25 mm.

Color, light brown, the legs with five or six bands of red.

One specimen, a young female, was taken by the *Fish Hawk* in 47 fathoms about 25 miles off Cape Lookout.

Genus SESARMA Say.

Sesarma Say, 1817, p. 76.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Lateral margin of carapace with a tooth behind the outer orbital tooth; body strongly convex above .... *reticulata.*
aa. Lateral margin of carapace without a tooth behind the outer orbital tooth; body nearly flat above .... *cinerea.*

Sesarma reticulata Say. Marsh crab. Pl. XXXVI, fig. 12.

Sesarma reticulata Say, 1817, p. 73; Gibbes, 1850, p. 180; Smith, 1869, p. 156; Coues, 1871, p. 121; Kingsley, 1878–79, p. 323; Sumner, 1911, p. 675; Fowler, 1912, p. 440, pl. 139.

Carapace rectangular, about one-fourth wider than long, convex, regions distinct, surface punctate and with scattered clumps of setæ above and in front; obliquely striate and setose on the posterolateral regions and with regular rows of low tubercles bearing short curved hairs on the inferolateral and frontal regions. The dorsal portion of the carapace overhangs the sides, and beneath the projecting shelf there is a line of cilia; front broad, slightly sinuate above basal segments of antennæ; anterolateral angle with a small tooth behind it.

Eyestalks short and stout. Chelipeds of male stout; the hand with a slight crest above and the meros with a low, smooth-edged crest along its anterior border; chelipeds of female similar, but much smaller. Walking legs hairy distally.

Measurements of a male: Length of carapace, 14 mm.; width, 16 mm.; width of front, 10 mm.; depth of body, 10 mm.

Color, dark olive, nearly black or purple.

This crab, which occurs from Cape Cod to the Gulf of Mexico, has been found in the Beaufort region in the salt marshes near Fort Macon, where it lives in burrows, similar to those of *Uca minax*, at about high-tide level. It has also been collected in a marsh on the mainland near Lenoxville and in the marshes along Newport River above Beaufort. The specimens from these localities and all the others we have seen alive were of a deep purple color, with the tips of the fingers white or yellowish.

Sesarma cinerea Say. Wharf crab, wood crab. Pl. XXXVI, fig. 11.

Sesarma cinerea Say, 1818, p. 442; Gibbes, 1850, p. 180; Coues, 1871, p. 121; Kingsley, 1878–79, p. 323; Smith, 1869, p. 157.

Similar to *S. reticulata*, but with the carapace somewhat narrower in proportion to its length and less convex; front not sinuate above bases of antennæ and lateral margin without a tooth behind the anterolateral angle.

Chelipeds with the hand shorter and less evidently crested than in *S. reticulata;* anterior margin of meros produced into a triangular denticulate plate. Walking legs with only a few scattered stiff hairs distally. Abdomen of the male broadest at third segment; fourth, fifth, and sixth, with sides gradually converging; seventh abruptly narrow and longer than broad.

Measurements of a male: Length of carapace, 13.5 mm; width, 15 mm.; width of front, 9 mm.; depth of body, 8 mm.

Color, brown, varying toward olive.

This little crab occurs throughout the region and is everywhere abundant. Throughout the warmer months of the year it is found crawling actively about on the wharves and stone jetties or resting in shallow burrows above tide mark along the shores. When pursued it scampers away with astonishing swiftness and if caught is always ready to escape by dropping off the legs by which it is held. Its eggs are produced in early summer although an occasional female with eggs may be found late in July or even in August.

Genus PLAGUSIA Latreille.

Plagusia Latreille, 1806, p. 33.

Plagusia depressa (Fabricius). Rock crab. Pl. XXXVI, fig. 10.

Cancer depressus Fabricius, 1775, p. 406.
Plagusia depressus Say, 1817, p. 100.
Plagusia depressa Rathbun, 1901, p. 19; Verrill, 1908, p. 332.

Carapace subhexagonal, wider than long, depressed, covered with flattened tubercles margined with short setæ; front broad, with a deep median furrow and deep notches for the antennules; a spiniform tubercle on each side between the median furrow and the antennulary notch; postorbital angle produced into a strong curved spine and followed, along the anterolateral margin, by three similar spines of diminishing size.

Chelipeds small and weak; hands and carpus broadly ribbed above, the ribs fringed with setæ; meros with three small spines above at the distal end. Walking legs strong, increasing in size from the first to the third, the fourth shorter than the second; dactyli strong and spinulose below; upper surface of all with anterior and posterior fringes of hairs, the posterior fringe the stronger and on the distal articles of the legs situated on the upper surface; meral articles flattened and with a strong spine near the distal end; second and third legs with a broad, dentate crest above on the basal article.

Length of carapace of a male, 21 mm.; width, 23 mm.

This crab is an accidental visitor from the south. Two specimens, both males, were collected in August, 1912, on the rock jetty on Shackleford Bank. Their presence there at that time was probably due to the heavy southwest winds which had blown continuously for almost two weeks.

Family OCYPODIDAE.

Brachyrhyncha having the body more or less distinctly quadrate, the front of moderate width or narrow, the eyestalks usually long and little or no gap between the third maxillipeds.

This family comprises 14 genera, of which 2 are represented within the Beaufort limits.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Eyestalks stout; chelipeds of male somewhat unequal .... *Ocypoda.*
aa. Eyestalks slender; chelipeds of male very unequal .... *Uca.*

Genus OCYPODE Weber.

Ocypode Weber, 1795, p. 92; Fabricius, 1798, p. 312.

Ocypode albicans Bosc. Sand crab. Pl. XXXVII, fig. 1.

Ocypode albicans Bosc, 1802, p. 196; Rathbun, 1901, p. 6; Sumner, 1911, p. 675; Fowler, 1912, p. 457, pl. 148, 149.
Ocypode arenarius Say, 1817, p. 69; Verrill, 1908, p. 306.
Ocypode arenaria H. Milne-Edwards, 1834–1840, t. II, p. 44; Coues, 1871, p. 122; Kingsley, 1878, p. 322.

Carapace quadrilateral, convex above from front to back, the sides nearly vertical and the front strongly deflexed; dorsal region finely granulate on middle and posterior portions, coarsely granulate toward the sides; a raised, dentate ridge marks off the dorsal region from the sides and is continued into a prominent acute angle at the outer corner of the orbit; a similar, but lower ridge extends upward and forward from the base of the fourth leg; orbits very large and open, extending all along the anterior margin on either side of the narrow front, both upper and lower margins crested and dentate.

Eyestalks large, club-shaped; the cornea covering over half the distal article. Antennules and antennæ much reduced, the flagellum of the former being hidden beneath the front. Chelipeds, in both sexes and even in the young, unequal, well developed, the larger chela with a vertical stridulating ridge of tubercles on the inner surface near the base of the movable finger; lower margin of hand thin and serrate; outer surface coarsely tuberculate. Ambulatory legs long, compressed, their margins with numerous tufts of stiff yellow hairs. Between the basal articles of the third and fourth legs, on the ventral surface, is a hair-fringed breathing slit.

Measurements of a female: Length of carapace, 42 mm.; width, 51 mm.

Color, gray or grayish white with yellow markings below and on the legs. Young very unlike the adults, being a mottled gray and brown.

The sand crabs are of the most characteristic animals of the region and occur in abundance along the ocean beaches and to some extent within the harbor. Their holes, which they dig to a depth from 2 to 4 feet, are to be found in large numbers near the extreme high-tide mark on the outer beaches, in smaller numbers still higher up and occasionally in the dunes, from an eighth to a quarter of a mile from the water. During the heat of the day they keep pretty well to their holes, though it is not at all unusual to find them out in the full glare of the noonday sun, but as evening approaches they sally forth in search of food and probably prowl about during the greater part of the night. At night they gather by the hundreds along the beach just at the edge of the water whence they rush down after each receding wave to pick up fragments of food left on the sand. At such times they enter the water without hesitation but do not go out from the shore more than a few feet. They are, also, to be found high up on the beaches and will gather in numbers about a fire built where they can see it. They will approach slowly until the heat becomes evident, then scurry away only to come back and repeat the performance.

When abroad in the daytime they are alert and are able to distinguish a large moving object a long distance off. If one of them is approached it moves away slowly and perhaps will attempt to hide. If it is pursued it runs with great rapidity until it finds a hole, either its own or that of another crab, into which it can dart. If a hole is not available it will take to the water, run out a few feet from the shore and settle into the sand.

The egg-laying season appears to be confined to the spring or very early summer. The only egg-bearing female we have seen collected was caught in a haul seine near Fort Macon in July, 1913. Only a few unhatched eggs remained of the large number that she had had a few days earlier, for her swimmerets were well covered with empty egg skins.

Genus UCA Leach. The fiddler crabs.

Uca Leach, 1814, p. 430; Rathbun, 1897b, p. 154.
Gelasimus Latreille, 1817, p. 517.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Carapace fully one and one-half times as wide as long; color dark, often with blue on the front; size small; large cheliped of male with an oblique tuberculate ridge on the inner surface.........*pugnax*.

aa. Carapace less than one and one-half times as wide as long.

  b. Thickness of body less than two-thirds the width of the carapace; color dark, usually with more or less grayish toward the front margin; size large; large cheliped of male with an oblique tuberculate ridge on the inner surface..*minax*.

  bb. Thickness of body two-thirds the width of the carapace; color light purplish gray mixed with brown; size small; large cheliped of male without a tuberculate ridge on the inner surface..*pugilator*.

Uca minax (Le Conte). Large fiddler crab. Pl. XXXVII, fig. 3.

Gelasimus minax Le Conte, 1855, p. 403; Coues, 1871, p. 121; Kinglsey, 1880, p. 148; Paulmier, 1905, p. 147.
Gelasimus vocator Kingsley, 1880a, p. 399.
Uca minax Rathbun, 1900, p. 585; Sumner, 1911, p. 675; Fowler, 1912, p. 450, pl. 144, 145.

Carapace quadrilateral, about one and one-third times as wide as long, convex and nearly smooth above; front deflexed; lateral regions nearly vertical; anterolateral angle slightly produced, continued backward and inward as a low, but well-defined ridge and, above the orbits, entirely across to the opposite side as a low revolute ridge; a semicircular groove on each side inside the anterolateral angle. Orbits large and open, their lower margin dentate. Front rather narrow.

Eyestalks long, slender. Antennules and antennæ small, the flagellum of the former being hardly visible. Chelipeds in the male very unequal, in the female equal and of small size. Large hand of male tuberculate above and in front, ridged above, inner surface with a central, oblique tuberculated ridge; fingers strong, meeting only at their tips, their cutting edges tuberculate and with a few larger teeth at irregular intervals, immovable finger truncate at tip. Walking legs strong and sparsely hairy.

Measurements of a male: Length of carapace, 20 mm.; width, 30 mm.; length of large hand, 56 mm.

Color, chestnut brown becoming gray in front, chelipeds with red spots at the articulations, chelæ ivory white, legs olive or grayish brown.

This is the largest of the three fiddler crabs found in the region and is to be looked for in the marshes some distance back from the salt water. In such situations they dig holes, often considerably above high tide level, which penetrate to a depth of 1 or 2 feet. In the moat at Fort Macon and along the banks of the canal leading to the Neuse River *U. minax* may be found living where the water about them is almost perfectly fresh. In some cases they build at the mouth of their burrow a low chimney or roof over a short tunnel along the surface of the ground with the mud pellets which they bring up, but usually the excavated material is scattered at some distance from the burrow. Females with eggs have been found as late as August.

Uca pugnax (Smith). Mud fiddler. Pl. XXXVII, fig. 4.

Gelasimus vocans Gould, 1841, p. 325; De Kay, 1844, p. 14 (pt).
Gelasimus palustris Stimpson, 1859, p. 62 (pt.).
Gelasimus pugnax Smith, 1869, p. 131; Coues, 1871, p. 121; Kingsley, 1878–79, p. 322; Paulmier, 1905, p. 147.
Gelasimus vocator Kingsley, 1880, p. 147.
Uca pugnax Rathbun, 1900, p. 585; Sumner, 1911, p. 675; Fowler, 1912, p. 454, pl. 146, 147.

Carapace one and one-half to one and three-fifths times as wide as long. Large hand of male slender, its inner surface with a tuberculate ridge like that of *U. minax;* fingers long and slender, widely gaping at base and meeting only at their tips; movable finger strongly curved, evenly denticulate; immovable finger with one larger tooth near the middle, its inferior border nearly straight, its tip sometimes depressed.

Measurements of a male: Length of carapace, 10.5 mm.; width, 17 mm.; length of large hand, 30 mm.

Color of carapace, dark olive, almost black, becoming bluish on the front; chelipeds brownish yellow; legs brown.

This species, which appears to combine the characters of *U. minax* and *U. pugilator*, is in most cases readily distinguishable by the characters given above. In habits it is most like *U. minax*, frequenting salt marshes and seldom or never occurring on the beaches as does *U. pugilator*, but is seldom found at any great distance from the water.

Uca pugilator (Bosc). Sand fiddler. Pl. XXXVII, fig. 2.

Ocypoda pugilator Bosc, 1802, t. 1, p. 197.
Gelasimus pugilator Latreille, 1817, p. 520; Coues, 1871, p. 121; Kingsley, 1880, p. 150; Paulmier, 1905, p. 147.
Gelasimus vocans De Kay, 1844 (pt), p. 14.
Uca pugilator Rathbun, 1900, p. 585; Sumner, 1911, p. 675; Fowler, 1912, p. 446, pl. 142, 143.

Carapace less than one and one-half times as wide as long, gastric and cardiac regions separated by a distinct transverse line, lateral border often with a line of granules just within the margin. Large hand of male without the tuberculate ridge possessed by *U. minax* and *U. pugnax* and with the fingers stronger than those of the latter species and with larger teeth placed at irregular intervals; inferior surface of immovable finger convex.

Measurements of a male: Length of carapace, 12 mm.; width, 17.5 mm.; length of large hand, 25 mm.

Color, purplish gray of varying shades with irregular markings of brown or dark gray; hand of male white, more or less suffused at the base with purple.

This is the smallest and most abundant fiddler crab of the region and is found in countless numbers on the sandy and muddy beaches of the harbor and the creeks tributary to it. This species lays its eggs in the spring and early summer, and by August the young, from 2 to 5 mm. across, may be found among the droves of adults.[a]

Subtribe OXYRHYNCHA.

Brachygnatha having the body more or less triangular in form, the fore part narrow, usually forming a distinct rostrum, and the orbits usually incomplete.

This subtribe comprises three families, of which two are represented in the Beaufort fauna.

Family INACHIDAE. The spider crabs.

Oxyrhyncha having the chelipeds not a great deal larger than the other legs and the fingers not bent at an angle with the hand, the second article of the second antenna well developed but usually fused with the epistome and often with the front, the orbits generally more or less incomplete and the body usually more or less covered with hooked hairs.

No less than 145 genera are assigned to this family, 14 of which are represented in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Basal article of antenna extremely slender throughout its length and usually long; eyes without orbits and not concealed.
  b. Carapace elongate, narrowed in front; external maxillipeds somewhat pediform, with the palp large and coarse and the meros usually narrower than the ischium; basal article of antenna usually subcylindrical.
    c. Rostrum extremely long; dactyli of walking legs as long as or longer than the propodi.
      d. Carapace smooth, even above; antennæ concealed beneath the rostrum.......... *Stenorynchus*.
      dd. Carapace rough and uneven above; antennæ long, flagella exposed.......... *Metoporhaphis*.
    cc. Rostrum short; dactyli of walking legs shorter than the propodi.................. *Podochela*.
  bb. Carapace usually subtriangular; external maxillipeds with the meros at least as broad as the ischium and the palp small; basal article of antenna flattened or concave ventrally.
    c. Inner crest of basal article of antenna very prominent and projecting downward at right angles to the outer crest; rostrum simple.. *Collodes*.

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[a] For an account of the habits of this and other fiddler crabs, see Pearse: Smiths. Rept. for 1913, p. 415-428, 1914.

cc. Inner crest of basal article of antenna advanced to the line of the front, or nearly so; rostrum bifid . . . . *Euprognathus.*
aa. Basal article of antenna not slender, often very broad; eyes with orbits or capable of concealment.
b. Eyes without true orbits.
c. Eyestalks short, sunk in the sides of a huge rostrum formed of two contiguous horns . . . . *Sphenocarcinus.*
cc. Eyestalks not short, concealed beneath long, curved supraocular horns; rostrum consisting of two curved, divergent horns . . . . *Tyche.*
bb. Eyes with true orbits.
c. Orbits with a large, blunt, cupped postocular process into which the eye is retractile, but is not entirely concealed.
d. Carapace covered with short hairs, rostrum double . . . . *Pelia.*
dd. Carapace nearly or quite naked, rostrum single . . . . *Pyromaia.*
cc. Orbits complete, wholly concealing the retracted eyes.
d. Fingers spoon-shaped at tips.
e. Carapace suboblong or suboval; legs not spiny . . . . *Pitho.*
ee. Carapace subtriangular; legs spinous . . . . *Mithrax.*
dd. Fingers acute at tips.
e. Orbits tubular, directed outward; carapace subtriangular or oblong.
f. Carapace with lateral spines . . . . *Stenocionops.*
ff. Carapace without lateral spines . . . . *Macrocœloma.*
ee. Orbits not tubular, directed obliquely forward.
f. Carapace orbicular . . . . *Libinia.*
ff. Carapace subpyriform, somewhat depressed . . . . *Microphrys.*

Genus PODOCHELA Stimpson.

Podochela Stimpson, 1860, p. 194.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Rostrum broad, rounded in front . . . . *riisei.*
aa. Rostrum drawn out into a slender point . . . . *gracilipes.*

Podochela riisei Stimpson. Pl. XXXVII, fig. 9.

Podochela riisei Stimpson, 1860; p. 196; Rathbun, 1901, p. 54; Verrill, 1908, p. 398.
Podochela reisei A. Milne-Edwards, 1880, p. 193.
Coryrhynchus riisei Kingsley, 1880, p. 384.

Cephalothorax pyriform, depressed, the greatest width near the posterior margin about two-thirds the length; rostrum broad, rounded in front, deeply excavated below for the antennules, carinate above and with a tuft of curled hairs; orbits rounded, their margins thickened and with a row of hairs; dorsal region uneven and with tufts of hairs. Sternum of male thrown into ridges which radiate to the bases of the legs.

Eyestalks short and stout, the cornea oblique; basal segment of antenna with a high crest on each margin; chelipeds slender in both sexes, the fingers in contact throughout their length; first pair of ambulatory legs considerably stouter than the others, about three times as long as the carapace; upper surface of all the legs with regularly spaced tufts of stiff, curled hairs.

Length of a male, 15 mm.; width, 10 mm.

Several specimens of this homely crab are reported to have been taken among hydroids at Beaufort. It may have occurred in former years but there is no recent record of it having been collected anywhere within the harbor. During the seasons of 1913 and 1914 a few specimens came in from the *Fish Hawk* dredgings. Two of these, from stations D7943 and D8204, have the chela like that described for *P. macrodera*, stout, the propodus dilated, and the fingers gaping at the base; otherwise they agree with the present species.

Podochela gracilipes Stimpson. Pl. XXXVII, fig. 6.

Podochela gracilipes Stimpson, 1871, p. 126; A. Milne-Edwards, 1879, p. 192; Rathbun, 1894, p. 50.

Cephalothorax pyriform, depressed, about two-thirds as wide as long; rostrum drawn out into a slender point, nearly flat above and with curled hairs along the margin; dorsal region uneven, as in *P. riisei*, but with very few crispate hairs; crests on basal article of antenna less pronounced than in *P. riisei* and with the dactylus of the first pair more than one-third as long as the propodus.

Dimensions of a female: Length of carapace, 9.75 mm.; width, 6.5 mm.

One specimen was taken by the *Fish Hawk* in 47 fathoms about 23 miles east of Cape Lookout. The species is readily distinguished from both *P. riisei* and *P. macrodera* by the shape of the rostrum.

Genus METOPORHAPHIS Stimpson.

Metoporhaphis Stimpson, 1860, p. 198.

Metoporhaphis calcaratus (Say). Pl. XXXVII, fig. 5.

Leptopodia calcarata Say, 1818, p. 455.
Metoporhaphis calcarata Stimpson, 1860, p. 198.
Metoporhaphis calcaratus A. Milne-Edwards, 1880, p. 174; Rathbun, 1894, p. 45.

Carapace triangular, very uneven, nodulose, each nodule surmounted by a tubercle and this in turn usually with a pencil of soft, hooked hairs; rostrum as long as or longer than the carapace, subcylindrical, upcurved, trispinous at the extreme tip.

Legs slender, the articles cylindrical but somewhat crooked; each leg with a strong terminal spine on the superior surface of the meral article; dactyli of all the legs with a double fringe of hairs.

Chelipeds comparatively small, less than half as long as first ambulatory legs; meral article with a marginal row of spines; carpus with a spine; hand with an incurving row of stiff bristles along each margin; fingers weak, widely gaping at base.

Measurements of a female: Length of carapace and rostrum, 21 mm.; length of rostrum, 10.5 mm.; width of carapace, 10 mm.

Color, a dirty gray.

Not uncommon among hydroids and ascidians at Beaufort, but most frequently obtained by dredging in Bogue Sound off Morehead City.

Genus EUPROGNATHA Stimpson.

Euprognatha Stimpson, 1871, p. 122.

Euprognatha rastellifera Stimpson. Pl. XXXVII, fig. 7.

Euprognatha rastellifera Stimpson, 1871, p. 123; A. Milne-Edwards, 1878, p. 183; Rathbun, 1898, p. 253; ibid., 1901, p. 58.
Euprognatha rastellifera spinosa, Rathbun, 1894, p. 55.

Carapace a little longer than wide, granulate, and with spines on the gastric, cardiac, and branchial regions and on the supraorbital margin; postorbital angle tapering to a slender point; rostrum considerably advanced, notched at the tip, the teeth short, triangular; basal joint of antenna with a slender spine directed obliquely forward and equally advanced with the front; interantennular spine inclined downward, equaling or surpassing the front. Sternum regularly granulated except on concave portion between the chelipeds.

Chelipeds nearly twice as long as carapace, granulate or spinous; hand swollen; fingers more than half the length of the palm, gaping slightly for about half their length. Ambulatory legs granulate, with tufts of curled setæ and often small spines.

Length of a male, 14.4 mm.; width, 12 mm.

Probably extralimital. Although the northern and southern limits of the range of this species easily include the entire Carolina coast, it has not as yet been found in the Beaufort region. It is probably to be looked for on the edge of the continental slope.

Genus PYROMAIA Stimpson.

Pyromaia Stimpson, 1871, p. 109.

Pyromaia cuspidata Stimpson. Pl. XXXVIII, fig. 4.

Pyromaia cuspidata Stimpson, 1871, p. 110; A. Milne-Edwards, 1879, p. 197, pl. XXXVI, fig. 2; Rathbun, 1894, p. 73.
Apiomaia cuspidata Von Martens, 1871, p. 182; Miers, 1879, p. 651.

Carapace triangular, about two-thirds as wide as long, somewhat tumid, granulate, and spiny. Rostrum tapering to a point, spinulose along the margins. Orbits large, open, with a supraorbital, postorbital, and two preorbital spines, the latter belonging to the basal article of the antenna and the posterior one of them directed downward. Mid-dorsal line with five erect spines—two on the gastric area, two on the cardiac area, and one on the first segment of the abdomen—the first three of these spines stand vertically but the last two are directed backward. Mesogastric and branchial areas each with one or two large and several small spines.

Antennulary septum prolonged downward into a sharp, triangular tooth. Chelipeds exceeding the rostrum by about the length of the fingers, weak, sparsely hairy, and with an irregular border of small spines. Walking legs long and slender, the meral articles spiny at the distal end, the dactyli long, slender, and curved.

Length of a male, 16 mm.; width, 9 mm.

Color, brown, the legs with lighter cross bands.

This species has been collected on the fishing banks in about 15 fathoms on two occasions. A small male was secured in 1914 and 5 specimens, 3 males and 2 females, in 1915. They are all immature but do not differ materially from larger specimens from the Florida coast.

Genus STENORYNCHUS Lamarck.

Leptopodia Leach, 1815, p. 15 (not *Leptopodia* Leach, 1814, p. 431).
Stenorynchus Lamarck, 1818 (pt.), p. 236 (not *Stenorhynchus* Latreille, 1825, nor *Stenorynchus* H. Milne-Edwards, 1834).

Stenorynchus sagittarius (Fabricius). Arrow crab. Pl. XXXVII, fig. 8.

Cancer sagittarius Fabricius, 1793, t. II, p. 442.
Leptopodia sagittaria Leach, 1815, p. 16.
Stenorynchus seticornis Lamarck, 1818, p. 237.
Stenorynchus sagittarius Rathbun, 1901, p. 53; Verrill, 1908, p. 397.

Carapace triangular, broadest behind, diminishing in width to the eyes and thence produced into the slender, flattened, laterally spinuliferous rostrum, which varies from slightly longer than the carapace to twice as long; there is a small postorbital spine.

Legs very slender and composed of cylindrical articles which bear spines at their distal ends and scattered spines near the middle of their length; the first pair of ambulatory legs is from eight to eight and a half times as long as the carapace; the second, third, and fourth legs successively shorter.

Chelipeds slender, cylindrical; hand weak, dactylus contained from two and a half to four times in the length of the propodus.

Measurements of a male: Length of carapace and rostrum, 45.3 mm.; length of rostrum, 23.2 mm.; width of carapace, 19 mm.

Color, creamy white or buff, with bands of brown or black diverging from the median line to the posterior margin; fingers blue; spines of rostrum, legs, and teeth of chelæ orange or red.

An occasional specimen of this curious crab has been taken by the *Fish Hawk* during the dredging operations off Beaufort Inlet and Cape Lookout. A number of fine examples were secured in 1914 on the Blackfish Banks and to the southward.

Genus PELIA Bell.

Pelia Bell, 1835, p. 170.

Pelia mutica (Gibbes). Pl. XXXVIII, fig. 7.

Pisa mutica Gibbes, 1850, p. 171.
Pelia mutica Stimpson, 1860, p. 177; Kingsley, 1878–79, p. 316; A. Milne-Edwards, 1880, p. 73; Rathbun, 1901, p. 62; Sumner, 1911, p. 670.

Carapace pyriform, regions elevated, covered everywhere with a thin coating of soft hair; rostrum about two-fifths as long as rest of carapace and composed of two horns united at the base but divergent distally.

Chelipeds rather long; in the male about as long as body, feeble; fingers sharp-pointed, finely denticulate, and in contact distally. First pair of legs larger than the others; last pair much reduced in size.

Dimensions of a male: Length, 9.5 mm.; width, 5.8 mm.

Occasionally found among the hydroids and sponges growing on wharf piles. The carapace and legs are usually covered with such a thick growth of sponge that it is only after tediously removing the foreign objects that the crab can be definitely seen.

Genus LIBINIA Leach.

Libinia Leach, 1815, p. 129.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Median line of carapace with about six spines...*dubia*.
aa. Median line of carapace with about nine spines...*emarginata*.

Libinia emarginata Leach. Spider crab. Pl. XXXVIII, fig. 6.

Libinia emarginata Leach, 1815, p. 130; Smith, 1879, p. 45; Rathbun, 1892, p. 235; Paulmier, 1905, p. 145; Sumner, 1911, p. 670; Fowler, 1912, p. 386.

Libinia canaliculata Say, 1817, p. 77; H. Milne-Edwards, 1834-1840, t. 1, p. 300; Gibbes, 1850, p. 169; Coues, 1871, p. 120; Kingsley, 1878-79, p. 316.

Carapace orbicular, about one-sixth longer than wide, spinous and tuberculate, and with a dense covering of short hairs. The larger spines are arranged as follows: A median row of about nine, extending from near the base of the rostrum to the posterior border; two subhepatic, of which the anterior is the longer; a lateral row of five; two spines, in addition to the median one, just above the posterior border; and about three on the branchial region; spiniform tubercles are scattered about among the larger ones. Rostrum slightly depressed, emarginate, or bifid at tip; a median groove between the eyes. A deep groove marking off the gastric region. Orbits with a prominent preorbital spine, two smaller spines beneath, on the basal article of the antenna, and one fissure above and one beneath.

Chelipeds equal, larger in the male; hands granulate, fingers smooth, evenly denticulate and about half as long as hand. Ambulatory legs long, hairy, unarmed, often unequal and asymmetrical—the result, perhaps, of injury and subsequent regeneration.

Color, a brownish or dirty yellow.

Length of a female, 62 mm.; greatest width, 58 mm.

Not uncommon in Beaufort Harbor.

Libinia dubia H. Milne-Edwards. Spider crab. Pl. XXXVIII, fig. 5.

Libinia dubia H. Milne-Edwards, 1834-1840, t. 1, p. 300; Gibbes, 1850, p. 169; A. Milne-Edwards, 1880, p. 129; Paulmier, 1905, p. 145; Sumner, 1911, p. 670; Fowler, 1912, p. 114.

Very similar in general characters to *L. emarginata* but with a more pyriform carapace and fewer spines. There are but six spines in the median row; the preorbital, subhepatic, and lateral spines are stronger than in *L. emarginata*, but the spiniform tubercles are few or wanting altogether, and the rostrum is slightly longer and more definitely bifid. The antero-lateral angle of the buccal frame is spinous in the present species.

Length of carapace of a male, 85 mm.; width, 75 mm.

This is the more common species in Beaufort Harbor and can usually be collected when wanted in the shallower water under the wharves along the town front. Occasionally large individuals are found on Bird Shoal in pools left by the falling tide; less frequently a specimen is brought up in the dredge. Immature individuals are often completely overgrown with sponges, hydroids, or ascidians, but the larger ones are usually nearly clean. Neither this nor the preceding species appear to be as abundant at Beaufort as they are farther north.

Genus MACROCŒLOMA Miers.

Macrocœloma Miers, 1879, p. 665.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Carapace with dorsal spines in addition to the epibranchial and posterior spines.......*camptocerum*.
aa. Carapace without dorsal spines in addition to the epibranchial and posterior spines...*trispinosum*.

Macrocœloma trispinosum (Latreille). Pl. XXXVIII, fig. 11.

Pisa trispinosa Latreille, 1825, p. 142.
Pericera trispinosa H. Milne-Edwards, 1834–1840, t. 1, p. 336; A. Milne-Edwards, 1880, p. 52.
Macrocœloma trispinosum Miers, 1879b, p. 665; Rathbun, 1901, p. 74; Verrill, 1908, p. 414.

Carapace irregularly triangular, with a velvety covering of short brown hairs; the mid-dorsal region much elevated and bearing four low rounded tubercles, one on the gastric, one on the cardiac, and one on each epibranchial region; posterolateral angle prolonged into a strong flattened spine which is directed outward and somewhat backward; posterior margin with a broad, triangular projection the tip of which may be slightly recurved; front formed of two somewhat flattened horns which are nearly parallel at the base but gradually curve away from each other at the tip.

Basal article of antenna with its inner angle produced, greatly exceeding the frontal margin and forming on each side of the bifurcate rostrum a broad spine directed obliquely outward.

Chelipeds weak; the meros nodose; the hand small with short fingers, the movable one of which is lightly furrowed above.

Length of a male, 27 mm.; width, 25 mm.

One young individual of this species has been found among seaweeds in the harbor. Others have been found outside the harbor in floating masses of *Sargassum* and it has been brought up in the dredge at the Blackfish Banks.

Macrocœloma camptocerum (Stimpson). Pl. XXXVIII, fig. 12.

Pericera camptocera Stimpson, 1870, p. 112; A. Milne-Edwards, 1873, p. 57.
Macrocœloma camptocera Miers, 1886, p. 79, 80; Rathbun, 1892, p. 249; ibid, 1898, p. 257.

Carapace irregularly triangular, sparsely covered with light-colored, stiff, curled hairs and with four strong spines on the dorsal region—one on the gastric, one on the cardiac, and one on each epibranchial lobe; posterolateral angle prolonged into a strong, acute, conical spine directed obliquely outward and backward; posterior margin with a conical, acute, somewhat recurved spine; front composed of two rather strongly divergent horns.

Basal article of antenna with its inner angle produced into a rather slender, curved spine which is directed obliquely outward and forward about midway between the orbit and the rostral horn. Chelipeds weak, smooth throughout; hand small, fingers short and not grooved above.

Length of a female, 24 mm.; width, 20 mm.

Color, a dirty brown.

Two specimens were obtained by the *Fish Hawk* on the fishing banks in water 14 fathoms deep.

Genus MITHRAX Latreille.

Mithrax Latreille, 1817, p. 23.
Trachonites Latreille in Desmarest, 1823, p. 263.
Mithraculus White, 1847, p. 7.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Carapace with oblique, parallel branchial grooves..*forceps*.
aa. Carapace without oblique, parallel branchial grooves.
  b. Rostral horns about as long as broad..*depressus*.
  bb. Rostral horns shorter, broader than long..*pleuracanthus*.

Mithrax forceps (A. Milne-Edwards). Pl. XXXVIII, fig. 1.

Mithraculus forceps A. Milne-Edwards, 1873–1880 [1875], p. 109.
Mithraculus hirsutipes Kingsley, 1880, p. 389.
Mithrax forceps Miers, 1886, p. 88; Rathbun, 1901, p. 70.

Carapace about one-fifth wider than long, deeply sculptured in the young but becoming smoother with age; anterolateral border with four tubercles (apart from the outer orbital spine) the last two or three of which are usually acute and turned forward at the tip; from near the bases of the first, second, and third teeth three broad grooves run diagonally backward over the branchial area thus leaving two well-defined unbroken ridges on this part of the carapace; the cardiac and gastric regions are crossed by less sharply defined ridges which are more or less broken up into low, rounded tubercles; front with a broadly V-shaped, median notch on each side of which is a rounded lobe; superior and inferior anteorbital teeth of about equal size and not greatly exceeding the postorbital teeth.

Chelipeds strong; meros with two strong spines or tubercles in front, five much smaller ones along posterior margin and usually two on the upper surface near the posterior margin; carpus entirely smooth or with a small spine near inner distal angle; hand smooth, polished, and somewhat tumid; fingers stout, widely gaping at the base but with expanded, hollowed-out tips; movable finger with a single large tooth at basal third or with two or three small teeth; immovable finger with from one to three teeth at the middle. Ambulatory legs spiny or denticulate and with many fine hairs.

Dimensions of a male: Length of carapace, 13 mm.; width, 16 mm.

Color, red, approaching vermilion and with little or no trace of purple.

This species, which was formerly thought to be the common *Mithrax* of the Beaufort region, is unquestionably much less abundant than the next, *M. depressus*. The two species, so far as can be determined, live together under the same conditions on the Blackfish Banks. Neither has ever been taken within the harbor or close to the shore.

Mithrax depressus A. Milne-Edwards. Pl. XXXVIII, fig. 2.

Mithrax depressus A. Milne-Edwards, 1873-1880 [1875], p. 96; Rathbun, 1901, p. 68; Verrill, 1908, p. 407.

Carapace little if any wider than long, conspicuously tuberculate; spines of anterolateral border well developed, the anterior one or two inclined to be double, while the posterior one or two are acute and curved forward; on the gastric region there are five small tubercles in a transverse row and in front of these two pairs of tubercles, the anterior pair being at the base of the rostral horns; on the mesogastric region there are two tubercles on each side in a transverse line; on the cardiac region a group of three or four poorly defined ones and on the branchial area four rather strong tubercles and several smaller ones arranged more or less in three oblique rows which start at the anterolateral margin; front broadly notched; lower anteorbital tooth considerably exceeding the upper one, its tip acute and strongly incurved; postorbital teeth much smaller than the anteorbitals.

Chelipeds rather slender; meros with one blunt spine in front, five smaller ones on posterior margin and a few on upper surface; carpus with several small tubercles; hand rather slender, upper and lower borders nearly straight; fingers slightly gaping, dentate for nearly their entire length. Ambulatory legs dentate and hairy.

Dimensions of a male: Length of carapace, 15 mm.; width, 15.6 mm.

Color, brownish red.

It appears to be the commonest and most characteristic crab of the offshore banks, where it is found in company with *M. forceps*.

Mithrax pleuracanthus Stimpson. Pl. XXXVIII, fig. 3.

Mithrax pleuracanthus Stimpson, 1871, p. 116; Rathbun, 1901, p. 68.
Mithrax hispidus Rathbun, 1892 (pt.), p. 265.

Similar in all general characters to *M. depressus* but with the carapace broader in proportion to its length and with the anterolateral margins less arcuate. The rostral horns are shorter and wider and placed closer together, the interspace tending toward a narrow V-shape. The tubercles of the carapace differ in that the two of each pair on the mesogastric region are confluent. There are also small tubercles about the base of each lateral spine.

The two species are so much alike that, after they have been for a time in alcohol, only the closest study and the comparison with well authenticated specimens of both species will make their separation possible. It is probable, however, that living specimens of *M. pleuracanthus* may be readily recognized by their color, which, judging from comparatively fresh specimens in formalin, is a much deeper red with distinct crimson cast.

Three or four specimens were taken on the Blackfish Banks in 1913 and 1914.

Genus MICROPHRYS H. Milne-Edwards.

Microphrys H. Milne-Edwards, 1851, p. 251.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Carapace without lateral laminiform processes; one branchial spine .... *bicornutus*.
aa. Carapace with two lateral laminiform processes; two branchial spines .... *platysoma*.

Microphrys bicornutus (Latreille). Pl. XXXVIII, fig. 10.

Pisa bicornuta Latreille, 1825, p. 141; Gibbes, 1850, p. 170.
Milnia bicornuta Stimpson, 1860, p. 51, 180.
Microphrys bicornutus A. Milne-Edwards, 1872, p. 247; ibid, 1873–1880 [1873], p. 61, pl. XIV, fig. 2–4; Rathbun, 1901, p. 72.

Carapace subpyriform, uneven and covered with rounded tubercles, among which are scattered hooked hairs. Rostrum composed of two stout, rather long horns which may diverge slightly from the base but are often nearly parallel; a strong spine below the front of the orbit; supraorbital spine well-developed and postorbital angle prominent. Branchial area with two or three short spines, the larger one of which usually curves upward.

Chelipeds moderately strong, the meral and carpal articles somewhat nodose; hand smooth, fingers about two-thirds as long as the palm.

Length, 14 mm.; width, 10.5 mm.

Color, in alcohol, light gray; in life, yellowish brown.

Three immature specimens of this species were obtained in 14 fathoms on the fishing banks off Beaufort in 1915.

Microphrys platysoma (Stimpson). Pl. XXXVIII, fig. 9.

Milnia platysoma Stimpson, 1860, p. 180.
Microphrys platysoma A. Milne-Edwards, 1873–1880, p. 62; Rathbun, 1901, p. 72.

Carapace slightly longer than wide, broadly subpyriform and depressed; surface thickly covered with tubercles and short, stout spines among which are bands and patches of crispate hairs; there are two or three strong spines on each branchial region, a prominent tuberculate boss on the cardiac region and a strong spine on the superior margin of the orbit; anterolateral margin with two laminiform processes, one on the branchial, the other on the hepatic region; rostral horns slender, acute, and directed straight forward. The spine of the basal article of the antenna extends obliquely outward and is about one-half the length of the rostrum.

Chelipeds rather weak, exceeding the rostral horns by less than the length of the hand; meros with a dentate, laminate, superior crest; carpus tuberculate; hand smooth, the palm about twice as long as broad; fingers widely gaping at the base. Ambulatory legs hairy, the meral and carpal articles with a strong spine.

Length of a male, 18 mm.; width, 16.5 mm.; length of rostrum, 5 mm.

Three specimens, one male and two females, were taken, at as many stations, on the Blackfish Banks by the *Fish Hawk* in 1914 at depths ranging from 13 to 16 fathoms.

Genus PITHO Bell.

Pitho Bell, 1836, p. 172.
Othonia Bell, 1836a, p. 55.
Piloronus Gistel, 1848, p. x (substitute for *Pitho* Bell).
Engyzomaria Gistel, loc. cit. (substitute for *Othonia* Bell).
Microrynchus Desbonne and Schramm, 1867, p. 20.

Pitho lherminieri (Desbonne and Schramm). Pl. XXXVIII, fig. 8.

Othonia lherminieri Desbonne and Schramm, 1867, p. 20; A. Milne-Edwards, 1875, p. 116 (not *O. lherminieri* Rathbun, 1892).
Othonia carolinensis Rathbun, 1892, p. 256.
Pitho lherminieri Rathbun, 1897, p. 8; Rathbun, 1901, p. 78.

Carapace as long as or longer than broad, oval; back with tubercles of various sizes and scattered hooked hairs; sides arcuate and armed with five strong teeth (exclusive of postorbital tooth) of which the first is the largest, the second and third are subequal, and the fourth and fifth are much smaller; eye sockets tubular, the distal extremity being bidentate and nearly or quite as advanced as the frontal teeth; the latter are short, conical, and separated by a V-shaped notch.

Antennæ short and fringed with stiff hairs, the first article coalesced with the carapace to form the floor of the orbit, the second article flattened and considerably produced into a lobe on the outer margin.

Chelipeds of full grown male from one and one-half to nearly two times as long as body, the meros subcylindrical while the carpus and hand are more or less compressed and distinctly angled along the margins.

Length of a male, 15 mm.; width, 14 mm.

Several specimens of this crab, mostly of small size, were brought in by the *Fish Hawk* in 1913 and 1914 from the Blackfish Banks. It has never been taken close to the shore.

Genus STENOCIONOPS Latreille.

Stenocionops Latreille, 1829, p. 59.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Carapace with about eight strong median spines .... *spinosissima.*
aa. Carapace with about four spiniform tubercles in the median line .... *furcata coelata.*

Stenocionops spinosissima (Saussure). Pl. XXXIX, fig. 2.

Pericera spinosissima Saussure, 1858, p. 10, pl. 1, fig. 2; A. Milne-Edwards, 1880, p. 52.
Pericera atlantica Rathbun, 1892, p. 247.
Pericera spinosissima Rathbun, 1898, p. 256.

Carapace oval, about one and one-half times as long as broad, granulate and covered with a sparse growth of short and fine curled hairs among which are a number of stout spines; about eight spines, larger and smaller, form a longitudinal median row extending from the front of the cardiac area to the posterior margin, there are two spines on each side on the mesogastric area and two, stronger than the others mentioned, well down on the branchial region; both the anterior and posterior orbital angles are spiniform, and behind the eye on the margin of the carapace is a spine; the rostral horns are stout, straight, and widely divergent. Basal article of antennæ armed in front with a flat spine much shorter than the orbital spines.

A single immature specimen was obtained by the *Fish Hawk* at station 7313, depth 69 fathoms, and another at a depth of about 50 fathoms 30 miles due south of Cape Lookout Lightship.

Stenocionops furcata cœlata (A. Milne-Edwards). Pl. XXXIX, fig. 3.

Pericera cœlata A. Milne-Edwards, 1879, p. 200, pl. XVa, fig. 3.
Pericera cornuta cœlata Rathbun, 1892, p. 244.
Stenocionops furcata cœlata Rathbun, 1901, p. 73.

Carapace pyriform, about one-half longer than wide, uneven, with strong spines and a dense covering of short setæ among which are many longer hooked hairs. Rostrum consisting of two nearly straight diverging horns with rows of hooked setæ; orbital region broad; preorbital spine strong; suborbital and postorbital spines much smaller. Mid-dorsal line with four strong spiniform tubercles, of which one is on the gastric region, while the other three are on the cardiac and intestinal regions; the most posterior spine has its tip curved forward. Lateral border with four stout spines, of which one is on the hepatic and the others on the branchial region. In addition to the spines mentioned there are two rather strong ones on the branchial region on each side and various smaller ones toward the front. Ventral surface of body and legs, except the distal articles of the chelipeds so closely covered with bulbose setæ that the shell is hidden.

Chelipeds slender; chelæ weak, the fingers less than half as long as the palm; meral article with a strong spine above near the distal end followed by several smaller spines. Walking legs more or less rough and with clusters of hooked hairs.

Length, including rostral horns, 60 mm.; width, including spines, 40 mm.; rostral horns, 18 mm.

Color, in life, dark red.

The large male described above and one immature specimen were obtained in 1915, in about 15 fathoms, on the fishing banks off Beaufort.

Genus SPHENOCARCINUS A. Milne-Edwards.

Sphenocarcinus A. Milne-Edwards, 1873–1880, p. 135.

Sphenocarcinus corrosus A. Milne-Edwards. Pl. XXXIX, fig. 1.

Sphenocarcinus corrosus A. Milne-Edwards, 1873–1880, p. 135; Rathbun, 1894, p. 66.

Carapace subtriangular, the lateral margin concave and the posterior one convex, depressed, deeply grooved, and prolonged anteriorly into a rostrum composed of two long cylindrical horns which in old individuals are slightly divergent at the tip. The grooves of the dorsal surface are deep and their surface is finely punctate. The elevations of the carapace are as follows: One gastric, placed longitudinally, a small circular lobe on each side; a cardiac, placed transversely with a deep notch on each side posteriorly; an intestinal, the outer ends of which extend outward along the posterior margin; a lateral, paired, extending from the lateral angle forward nearly to the eye; a small post ocular and a larger supraocular elevation on each side; the margins of these elevations are sharply defined and the surface is finely eroded.

Chelipeds rather small and weak. First pair of walking legs longer than any of the others and exceeding the chelipeds by more than the length of the dactyli.

Measurements of a male: Total length, 21 mm.; rostrum, 13 mm.; extreme width, 10 mm.

Color, orange red.

Four specimens of this remarkable little crab were brought in by the *Fish Hawk* from a depth of about 100 fathoms, 30 miles south of Cape Lookout. It has been recorded by Dr. Mary J. Rathbun from 90 fathoms off Cape Fear. In the specimens at hand an interesting variation is shown in the rostrum. In the largest individual, a female, the two horns extend straight forward and are in contact except close to the tip; their length is exactly equal to the extreme width of the carapace. In the next specimen, a male, the horns are proportionally longer, curved outward and are divergent for about the terminal half. In the next individual the horns are considerably shorter than the width of the carapace and in close contact throughout their length. In the last individual, 8 mm. wide, the location of the horns is occupied by a single conical process showing no indication of bifurcation.

Genus TYCHE Bell.

Tyche Bell, 1836a, p. 57.

Tyche emarginata White. Pl. XXXIX, fig. 4.

Tyche emarginata White, 1847, p. 206; Stimpson, 1871, p. 119; A. Milne-Edwards, 1873, p. 126.
Platyrhinchus trituberculatus Desbonne and Schramm, 1867, pl. III, figs. 7, 8.

Carapace about one and two-thirds times as long as wide, irregular and angular, prolonged in front into four long, cylindrical, curved horns, the median pair belonging to the rostrum and the lateral one springing from above the eyes; from the front the carapace slopes abruptly upward, the gastric regions being concave, to an irregularly octagonal dorsal area which has nodulose lateral borders and which is prolonged behind into a laminiform expansion that overhangs the base of the abdomen and the basal articles of the walking legs. The anterior margin, behind the base of the supra-orbital horns, is laminiform and divided by a deep, narrow fissure.

Eyestalks long, but projecting very little beyond the margin of the carapace. Antennæ concealed beneath the front. Third maxillipeds with the exopodite provided with a hook which overlaps the base of the ischium of the endopodite; ischium and meros with similar interlocking processes. Chelipeds short and weak. Walking legs of moderate size, their dactyli very long and slender.

Length, posterior margin to base of rostrum, 28 mm.; width, 20 mm.

A single specimen of this curious crab was brought in by the *Fish Hawk* from the fishing grounds (station 7944) where it was dredged in about 14 fathoms. It was completely overgrown with sponge, hydroids, bryozoans, and worm tubes, the entire mass being twice or three times the size of the crab. After the removal of as much of the foreign growth as could be taken off without injury to the specimen it proved to be a female with her abdominal pouch filled with eggs.

Family PARTHENOPIDAE. The long-armed crabs.

Oxyrhyncha having the chelipeds much larger than any of the other legs and with the fingers bent on the hand at an angle toward the side on which the immovable finger is set, the second article of the second antenna small, short and not fused with the epistome or the front, the orbits well formed, and hooked hairs very seldom present.

This family comprises 17 genera, of which 4 are represented in the Beaufort fauna.

KEY TO THE GENERA OF THE BEAUFORT REGION.

a. Carapace not laterally expanded.
  b. Carapace rough, tuberculate or subspinous.
    c. Carapace triangular, convex; pterygostomian and subhepatic regions not deeply excavated to form passages to the efferent branchial apertures.............................*Parthenope.*
    cc. Carapace subrhomboidal, depressed; pterygostomian and subhepatic regions excavated so as to form, in conjunction with the retracted chelipeds, passages to the efferent branchial apertures..*Platylambus.*
  bb. Carapace smooth..*Solenolambus.*
aa. Carapace expanded laterally to form a vault beneath which the walking legs are concealed, ...*Heterocrypta.*

Genus PARTHENOPE Weber.

Parthenope Weber, 1795, p. 92.
Lambrus Leach, 1815, p. 308, 310.

KEY TO THE SPECIES OF THE BEAUFORT REGION.

a. Margins of chelipeds denticulate or subspinous..*agona.*
aa. Margins of chelipeds with serrate tubercles and laciniate spines..........................*pourtalesii.*

Parthenope agona (Stimpson). Pl. XXXIX, fig. 5.

Lambus agonus Stimpson, 1871, p. 131; A. Milne-Edwards, 1873-1880 [1878], p. 151; 1879, pl. XXVIII, fig. 3; Rathbun, 1901, p. 79.

Carapace slightly (about one-eighth) broader than long, elevated along the middle line and with the branchial regions inflated; surface coarsely punctate and with many more or less spiniform tubercles, the larger of which are arranged as follows: Near the middle of the gastric region a transverse row of four; behind these a longitudinal row of four larger ones; one on each side, marking the ends of the posterior margin; four or five on each branchial region, the posterior one spiniform and turned obliquely outward; one on each hepatic region. The margin of the branchial region bears five or six small teeth; below and partly behind this is a short crest and below this a stout spine. Front produced, narrow at the tip but broad and with raised margins proximally. Orbit with an open fissure above and a broad gap below. A conical tubercle on the sternum at the base of the cheliped and a similar one on the coxal article of that appendage. Proximal segment of the abdomen with a sharp transverse crest forming a lobe in the center and a tooth on each side.

Chelipeds very long and slender, prismatic, finely rugose above, denticulate on both margins and with an additional row of denticles, median on the meros and carpus but approaching the outer margin on the hand; the denticles on the margins of the hand are much stronger distally. Ambulatory legs long, slender and nearly smooth.

Length of carapace, 16 mm.; width, 17.5 mm.

Color, light buff, more or less marbled with purple; chelipeds and legs with broad bands of purple.

One specimen, a female, was taken by the *Fish Hawk* 23 miles east of Cape Lookout in 47 fathoms.

Parthenope pourtalesii (Stimpson). Pl. XXXIX, fig. 6.

Lambrus pourtalesii Stimpson, 1871, p. 129.
Lambrus verrillii Smith, 1881, p. 415; ibid, 1883, p.14; ibid, 1887, p. 628 (24), pl. II, fig. 2.
Parthenope pourtalesii Verrill, 1908, p. 418.

Carapace triangular, nearly as long as broad, somewhat tumid in the mid-dorsal and branchial regions which are separated from each other by a pair of deep longitudinal depressions; surface everywhere minutely punctate or eroded; median line with four strong spiniform tubercles, one of which is on the gastric and three on the cardiac region; two small spines placed transversely in front of the gastric spine; branchial region with a conspicuous, laciniated spine at the posterolateral angle from which a row of two or three similar but smaller spines extends toward the gastric region; another row of from two to five extends along the posterior margin, and another row extends forward along the anterolateral margin. Rostrum directed obliquely downward, broad at the base and with conspicuous raised margins, but suddenly contracted near the tip.

Chelipeds long, slender, tuberculate and with a border of serrate tubercles and laciniate spines on both margins; meros with an additional median row of spiniform tubercles on the upper surface and the hand with an obsolete median row beneath. Meral articles of walking legs subspinous on both margins.

Measurements of male: Length, 9.5 mm.; width, 10 mm.; hand, 11.5 mm.

Color, purplish red with cross bands of buff on chelipeds and walking legs.

A series of four small specimens, one male and three females, was secured by the *Fisk Hawk* in about 100 fathoms, 30 miles south of Cape Lookout. They agree in essential characters with specimens of *P. pourtalesii* in the United States National Museum. No two specimens are exactly alike with respect to spines, but in all the breadth is slightly in excess of the length.

Genus PLATYLAMBRUS Stimpson.

Platylambrus Stimpson, 1871, p. 129.

Platylambrus serratus (H. Milne-Edwards). Pl. XXXIX, fig. 7.

Lambrus serratus H. Milne-Edwards, 1834–1840, t. I, p. 357.
Platylambrus serratus A. Milne-Edwards, 1873–1880 [1878], p. 156; Rathbun, 1901, p. 80.

Carapace subtriangular, about three fourths as long as wide, depressed, strewn with spines and tubercles; anterolateral margins curved, cut into seven or eight teeth and terminating posteriorly in a strong flat spine; posterolateral border with three short erect spines; on the back the spines are irregularly arranged, there being about eight prominent and numerous smaller ones on each branchial region and a median row of five, the anterior one of which is on the middle of the gastric region, while the posterior one is on the posterior margin. A pair of ridges converge from the orbits to the anterior median spine. Rostrum short, narrow and with raised margins which are continuous with the superior walls of the orbits.

Chelipeds, when extended, about twice as long as carapace, trigonal, smooth beneath, more or less tuberculate on upper surface and with the margins cut into lanceolate or triangular teeth which are fringed with fine hairs and much stronger on the outer than on the inner side of the articles; on the manus there are about nine teeth alternately large and small; fingers stout, very oblique. Ambulatory legs of moderate size, the longest not exceeding the meros of the cheliped.

Color, a rosy red more or less mottled with gray; fingers carmine, shading to black.

Dimensions of a male: Length, 17 mm.; width, 22 mm.; meros, 18 mm.; manus, 23 mm.

Several specimens were dredged by the *Fish Hawk* south and east of the fishing banks, about 15 or 20 miles off Beaufort Inlet. It has not been collected near the shore.

Genus SOLENOLAMBRUS Stimpson.

Solenolambrus Stimpson, 1871, p. 132.

Solenolambrus tenellus Stimpson. Pl. XXXIX, fig. 8.

Solenolambrus tenellus Stimpson, 1871, p. 134.
Pisolambrus nitidus A. Milne-Edwards, 1873–1880 [1878], p. 158, pl. XXX, fig. 4.

Carapace a little broader than long and about equally produced in front of and behind the line of the lateral angles, strongly convex, and with four protuberances—one gastric, one cardiac, and two branchial; surface naked, glossy, and rather coarsely punctate; margins crenulate and dentate, the five or six teeth of the expanded and broadly rounded lateral angle being the most prominent; posterolateral margin slightly concave; posterior margin convex, its angles obtuse. Hepatic region with two or three denticulate teeth, those of the gastric and cardiac regions obtusely rounded; ridge of the branchial region well marked near the posterolateral margin, but almost obsolete anteriorly. Rostrum rather prominent and faintly tridentate at the extremity, median tooth smallest and most prominent. Eyes large, with a very minute tubercle at the summit.

Chelipeds very long and slender, their general surface smooth and polished; their edges denticulate; meros with about 13 teeth on either edge, the third tooth from the distal end being larger than the others; hand with 12 sharp, forward-curving teeth on the superior edge, the terminal tooth above the finger being spiniform and considerably longer than the others; outer margin with about 11 small teeth; inner margin with 19 or 20 very minute teeth.

Length of a male, 6.25 mm.; width, 6.75 mm.; hand, 8 mm.; meros of cheliped, 7.25 mm.

One specimen, a female, was brought in by the *Fish Hawk* in 1902 from off Cape Lookout in 69 fathoms. It was taken to the United States National Museum for identification, but since its return to the laboratory has been lost.

Genus HETEROCRYPTA Stimpson.

Heterocrypta Stimpson, 1871, p. 102.

Heterocrypta granulata (Gibbes). Hexagon crab. Pl. XXXIX, fig. 9.

Cryptopodia granulata Gibbes, 1850, p. 173.

Heterocrypta granulata Stimpson, 1871, p. 102; Kingsley, 1878–79, p. 317; Rathbun, 1901, p. 83; Sumner, 1911, p. 669.

Carapace subtriangular, its length two-thirds its width; anterolateral margins nearly straight, forming a sharp, slightly sinuous edge from which the shell slopes upward to a prominent granulate ridge which runs nearly parallel with the margin on each side, is connected with its fellow in front by a short transverse ridge, and behind joins the ridge which forms the posterior margin of the shell; from the ends of the short anterior transverse ridge a pair of granulate crests run forward to the margins of the rostrum. On the cardiac region there is a large granulate boss. Except on the ridges and margins the carapace above is smooth. Sternum and lower surface of abdomen coarsely granulate. Third, fourth, and fifth segments of male abdomen fused.

Chelipeds unequal, rather heavy, and longer than the width of the carapace; outer and inner margins of upper surface of meros, carpus, and manus expanded into irregular granulate or dentate crests; fingers short, the movable one very oblique and, in the larger chela, meeting the thumb for only a short distance near the tip. Ambulatory legs short, almost completely hidden beneath the carapace.

Length of a female, 11 mm.; width, 17 mm.

Color, varying from light gray to nearly black, usually with these two colors more or less commingled so as to produce an irregular mottling or marbling.

This curious little crab is not infrequently brought to the surface by the dredge from the shelly bottoms off Morehead City and in other places about the harbor. Its angular form and its coloration bear so close a resemblance to the fragments of shells among which it lives that it is extremely difficult to detect it.

The females frequently bear eggs, as these appear to be produced throughout the summer.

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EXPLANATION OF PLATES.

The figures are from photographs taken by the senior author and unless otherwise indicated are of specimens collected in the region about Beaufort.

Plate XXV.

Fig. 1.—Sicyonia lævigata, ♂ and ♀, natural size.
Fig. 2.—Sicyonia edwardsii, ♂, natural size.
Fig. 3.—Sicyonia dorsalis, ♂, natural size.
Fig. 4.—Sicyonia brevirostris, ♀, ♀, natural size.
Fig. 5.—Peneus setiferus, ♂, natural size.
Fig. 6.—Peneus brasiliensis, ♂, ¾ natural size.
Fig. 7.—Parapenæus politus, ♂, natural size.
Fig. 8.—Parapenæus megalops, ♂, natural size.
Fig. 9.—Trachypeneus constrictus, ♂, natural size.

Plate XXVI.

Fig. 1.—Synalpheus townsendi, ♂ × 2.
Fig. 2.—Synalpheus longicarpus, ♂, × 2.
Fig. 3.—Synalpheus minus, ♀, × 2.
Fig. 4.—Crangon packardii, ♂, × 1½.
Fig. 5.—Crangon formosus, ♀, natural size.
Fig. 6.—Crangon heterochælis, ♂, natural size.
Fig. 7.—Automate kingsleyi, ♀, type, natural size.
Fig. 8.—Hippolyte pleuracantha, ♀, × 4.
Fig. 9.—Ogyris alphærostris, ♀, natural size.
Fig. 10.—Leucifer faxoni, ♂, × 6.
Fig. 11.—Concordia gibberosus, ♀, × 2, coast of South Carolina.
Fig. 12.—Hippolysmata wurdemanni, ♂, natural size.
Fig. 13.—Latreutes ensiferus, ♀, × 5.

Plate XXVII.

Fig. 1.—Crangon armillatus, ♂, natural size.
Fig. 2.—Tozeuma carolinense, ♂ and ♀, × 1½.
Fig. 3.—Palæmonetes exilipes, ♂, natural size.
Fig. 4.—Palæmonetes carolinus, ♂, × 2.
Fig. 5.—Palæmonetes vulgaris, ♂ and ♀, natural size.
Fig. 6.—Palæmon tenuicornis, ♀, natural size.
Fig. 7.—Urocaris longicaudata, ♂, × 4.
Fig. 8.—Coralliocaris wilsoni, ♂ and ♀, × 1½.
Fig. 9.—Crago septemspinosus, ♂, natural size.

Plate XXVIII.

Fig. 1.—Gnathophyllum modestum, ♀, type, natural size.
Fig. 2.—Scyllarus americanus, ♀, natural size.
Fig. 3.—Panulirus argus, young ♂, ½ natural size.
Fig. 4.—Cambarus diogenes, ♀, ½ natural size.
Fig. 5.—Cambarus blandingii, ♀, ½ natural size, Lake Mattamuskeet, N. C.
Fig. 6.—Cambarus uhleri, ♀, natural size, Dorchester County, Md.
Fig. 7.—Homarus americanus, young ♂, ⅓ natural size, coast of Massachusetts.
Fig. 8.—Munida irrasa, ♂, natural size.
Fig. 9.—Munida longipes, ♂, ½ natural size.

Plate XXIX.

Fig. 1.—Petrolisthes galathinus, ♂ and ♀, natural size.
Fig. 2.—Pachycheles rugimanus, ♀, natural size.
Fig. 3.—Euceramus prælongus, ♂, natural size.
Fig. 4.—Galathea rostrata, ♂, natural size, coast of Yucatan.
Fig. 5.—Callianassa stimpsoni, ♂, natural size.
Fig. 6.—Porcellana soriata, ♂, ×2½.
Fig. 7.—Porcellana sayana, ♀, natural size.
Fig. 8.—Polyonyx macrocheles, ♂ and ♀, natural size.
Fig. 9.—Upogebia affinis, ♂, natural size.
Fig. 10.—Callichirus major, ♂, natural size.
Fig. 11.—Catapagurus sharreri, ♂ and ♀, natural size.
Fig. 12.—Pagurus annulipes, ♂, ×3.
Fig. 13.—Pagurus longicarpus, ♂ and ♀, natural size.

PLATE XXX.

Fig. 1.—Pagurus pollicaris, ♂, ½ natural size.
Fig. 2.—Pagurus cokeri, ♂, natural size.
Fig. 3.—Paguristes moorei, ♀, natural size.
Fig. 4.—Pagurus corallinus, ♂, natural size.
Fig. 5.—Pylopagurus rosaceus, ♂, natural size.
Fig. 6.—Petrochirus bahamensis, ♂, natural size.
Fig. 7.—Paguristes armatus, ♀, natural size.
Fig. 8.—Emerita talpoida, ♀, natural size.
Fig. 9.—Clibanarius vittatus, ♂, natural size.
Fig. 10.—Homola barbata, ♀, natural size.
Fig. 11.—Albunea gibbesii, ♂, natural size.
Fig. 12.—Lepidopa websteri, ♀, natural size.

PLATE XXXI.

Fig. 1.—Ranilia muricata, ♂, natural size.
Fig. 2.—Hypoconcha arcuata, ♀, natural size.
Fig. 3.—Hypoconcha sabulosa, ♀, natural size.
Fig. 4.—Latreillia elegans, ♀, natural size.
Fig. 5.—Dromidia antillensis, ♂, natural size.
Fig. 6.—Calappa sulcata, ♂, natural size.
Fig. 7.—Calappa angusta, ♂, natural size.
Fig. 8.—Calappa flammea, ♂, natural size.
Fig. 9.—Osachila semilevis, ♂, natural size.
Fig. 10.—Osachila tuberosa, ♂, natural size.

PLATE XXXII.

Fig. 1.—Hepatus epheliticus, ♂, ¾ natural size.
Fig. 2.—Iliacantha subglobosa, ♂, natural size, Straits of Florida.
Fig. 3.—Iliacantha intermedia, ♂, natural size.
Fig. 4.—Speloeophorus nodosus, ♀ and ventral surface, natural size.
Fig. 5.—Speloeophorus pontifera, ♂, × 2.
Fig. 6.—Lithadia cariosa, ♂ and ♀, natural size.
Fig. 7.—Ovalipes ocellatus ocellatus, ♂, ⅔ natural size.
Fig. 8.—Ovalipes ocellatus floridanus, ♀, ¾ natural size.
Fig. 9.—Persephona punctata, ♂, ¾ natural size.

PLATE XXXIII.

Fig. 1.—Portunus gibbesii, ♂, ½ natural size.
Fig. 2.—Portunus sayi, ♂, natural size.
Fig. 3.—Portunus (Acheloüs) spinicarpus, ♂, natural size.
Fig. 4.—Portunus (Acheloüs) spinimanus, ♀, ¾ natural size.
Fig. 5.—Portunus (Acheloüs) sebæ, ♀, ¾ natural size, St. Thomas, W. I.
Fig. 6.—Portunus (Acheloüs) ordwayi, ♀, ¾ natural size, off Cape Lookout.
Fig. 7.—Portunus (Acheloüs) depressifrons, ♀, ¾ natural size, Key West, Fla.
Fig. 8.—Portunus (Acheloüs) anceps, ♂, natural size, Eleuthera Island, Bahamas.

PLATE XXXIV.

Fig. 1.—Callinectes sapidus, ♂, ½ natural size.
Fig. 2.—Callinectes ornatus, ♂, ¾ natural size.
Fig. 3.—Arenæus cribrarius, ♂, ⅔ natural size.
Fig. 4.—Eurypanopeus depressus, ♂ and ♀, natural size.
Fig. 5.—Lobopilumneus agassizii, ♀, natural size.
Fig. 6.—Leptodius agassizii, ♂, natural size.
Fig. 7.—Hexapanopeus angustifrons, ♂, natural size.
Fig. 8.—Neopanope texana sayi, ♂, natural size.
Fig. 9.—Panopeus herbstii, ♂, natural size.

PLATE XXXV.

Fig. 1.—Cancer irroratus, ♀, natural size.
Fig. 2.—Cancer borealis, young ♂, natural size.
Fig. 3.—Pilumnus lacteus, ♂, natural size.
Fig. 4.—Pilumnus sayi, ♂, natural size.
Fig. 5.—Rhithropanopeus harrisii, ♂ and ♀, Indian River, Fla.
Fig. 6.—Eriphia gonagra, ♂, natural size.
Fig. 7.—Eurytium limosum, ♂, ¾ natural size, Port Royal Island, S. C.
Fig. 8.—Menippe mercenaria, ♂, ½ natural size.
Fig. 9.—Pinnotheres ostreum, ♀, natural size.
Fig. 10.—Pinnotheres maculatus, ♂ and ♀, natural size.

PLATE XXXVI.

Fig. 1.—Dissodactylus mellitæ, ♀, × 8.
Fig. 2.—Pinnixa cylindrica, ♂ and ♀, natural size.
Fig. 3.—Pinnixa sayana, ♀, × 2.
Fig. 4.—Pinnixa chætopterana, ♂ and ♀, × 2.
Fig. 5.—Pinnixa cristata, ♀, type, × 2.
Fig. 6.—Planes minutus, ♂, natural size.
Fig. 7.—Euchirograpsus americanus, young ♀, natural size.
Fig. 8.—Euryplax nitida, ♂, × 1½.
Fig. 9.—Pachygrapsus transversus, ♂, natural size.
Fig. 10.—Plagusia depressa, ♂, natural size.
Fig. 11.—Sesarma cinerea, ♂ and ♀, natural size.
Fig. 12.—Sesarma reticulata, ♂ and ♀, natural size.

PLATE XXXVII.

Fig. 1.—Ocypode albicans, ♂, ½ natural size.
Fig. 2.—Uca pugilator, ♂ and ♀, natural size.
Fig. 3.—Uca minax, ♂ and ♀, natural size.
Fig. 4.—Uca pugnax, ♂ and ♀, natural size.
Fig. 5.—Metoporhaphis calcaratus, ♂ and ♀, natural size.
Fig. 6.—Podochela gracilipes, ♀, × 2.
Fig. 7.—Euprognatha rastellifera, ♂, × 1½.
Fig. 8.—Stenorynchus sagittarius, ♂, natural size.
Fig. 9.—Podochela riisei, ♂, natural size.

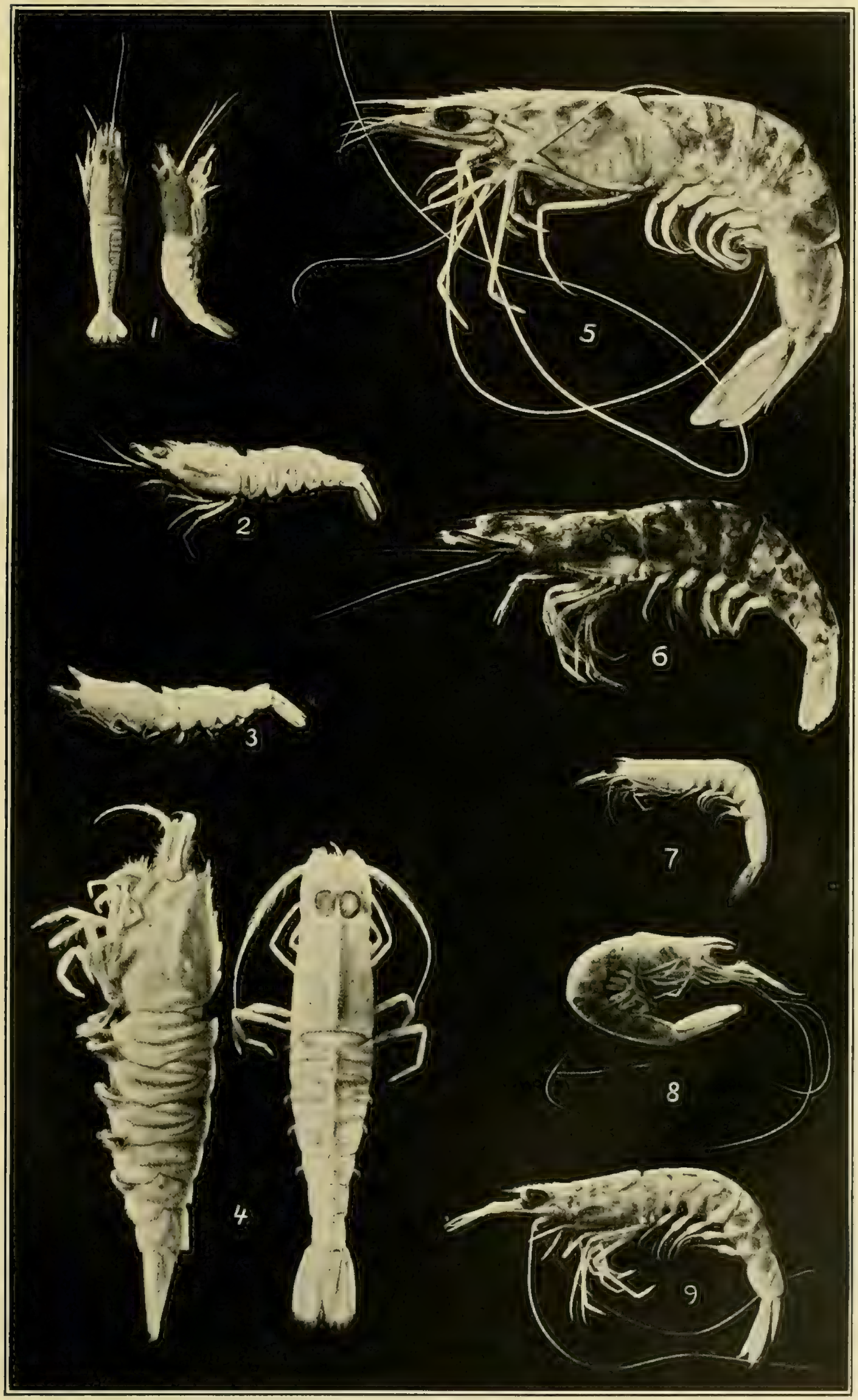
PLATE XXXVIII.

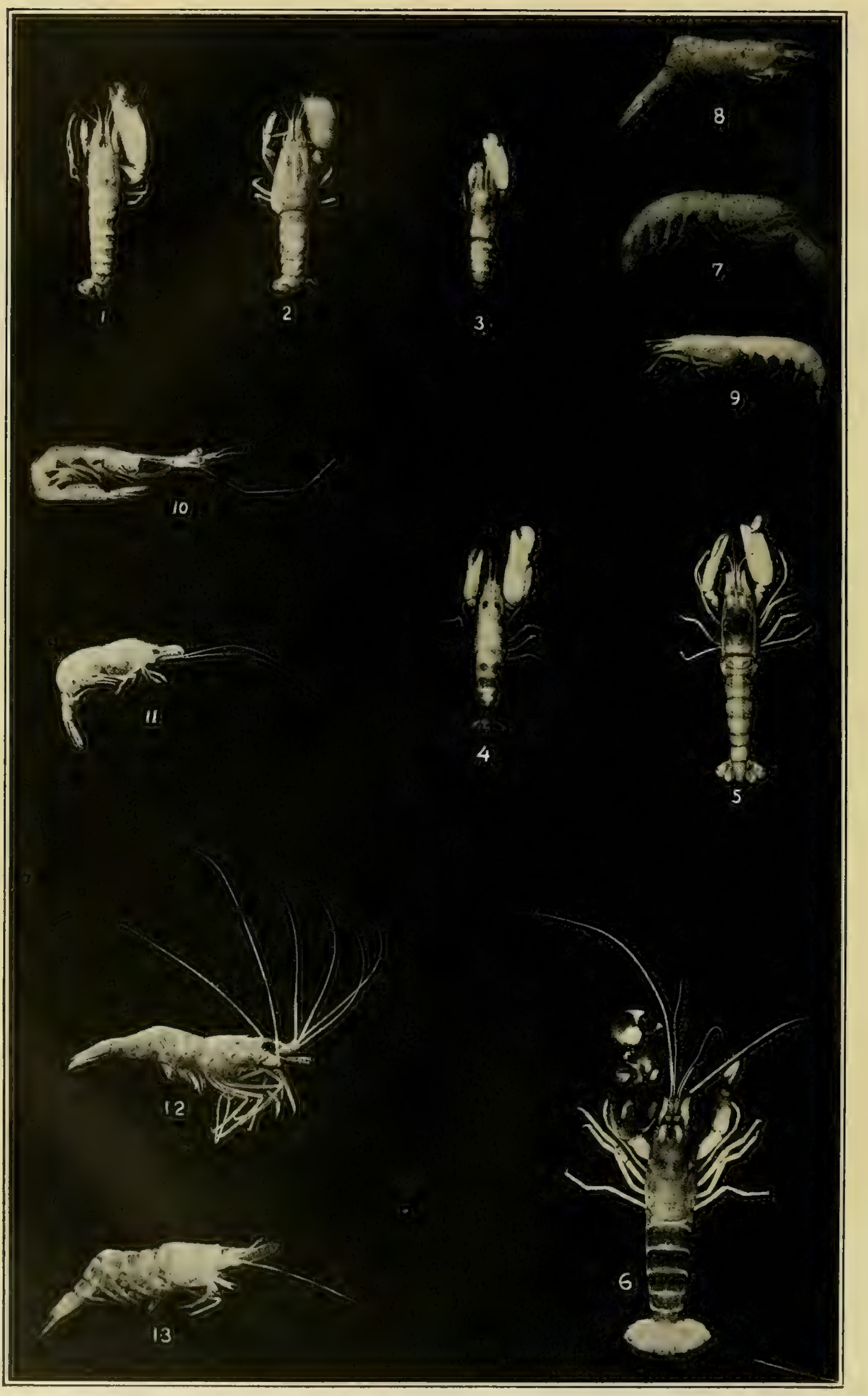
Fig. 1.—Mithrax forceps, ♂, natural size.
Fig. 2.—Mithrax depressus, ♂, natural size.
Fig. 3.—Mithrax pleuracanthus, ♂, natural size.
Fig. 4.—Pyromaia cuspidata, ♀, natural size.
Fig. 5.—Libinia dubia, ♀, ¾ natural size.
Fig. 6.—Libinia emarginata, ♂, ¾ natural size.
Fig. 7.—Pelia mutica, ♂, × 2.
Fig. 8.—Pitho lherminieri, young ♀, natural size.
Fig. 9.—Microphrys platysoma, ♂, × 1½
Fig. 10.—Microphrys bicornutus, young ♂, natural size.
Fig. 11.—Macrocœloma trispinosum, ♀, natural size.
Fig. 12.—Macrocœloma camptocerum, ♀, natural size.

PLATE XXXIX.

Fig. 1.—Sphenocarcinus corrosus, adult ♀ and two immature, natural size.
Fig. 2.—Stenocionops spinosissima, young ♂, ½ natural size.
Fig. 3.—Stenocionops furcata cœlata, ♂, ½ natural size.
Fig. 4.—Tyche emarginata, ♀, natural size.
Fig. 5.—Parthenope agona, ♀, natural size.
Fig. 6.—Parthenope pourtalesii, ♂, × 2.
Fig. 7.—Platylambrus serratus, ♂, natural size.
Fig. 8.—Solenolambrus tenellus, ♀, × 2.
Fig. 9.—Heterocrypta granulata, ♂ and ♀, natural size.

PLATE XXV.

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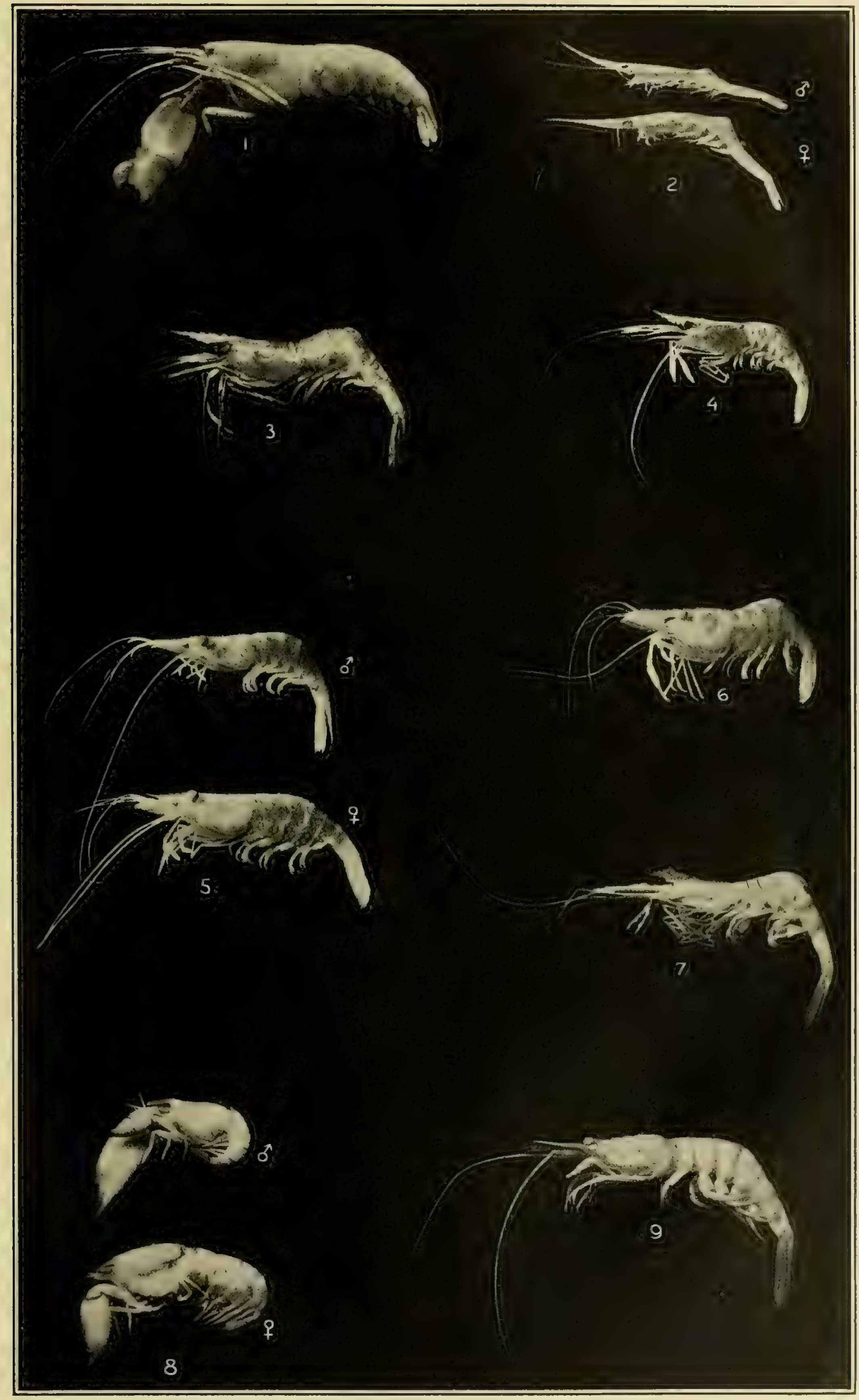
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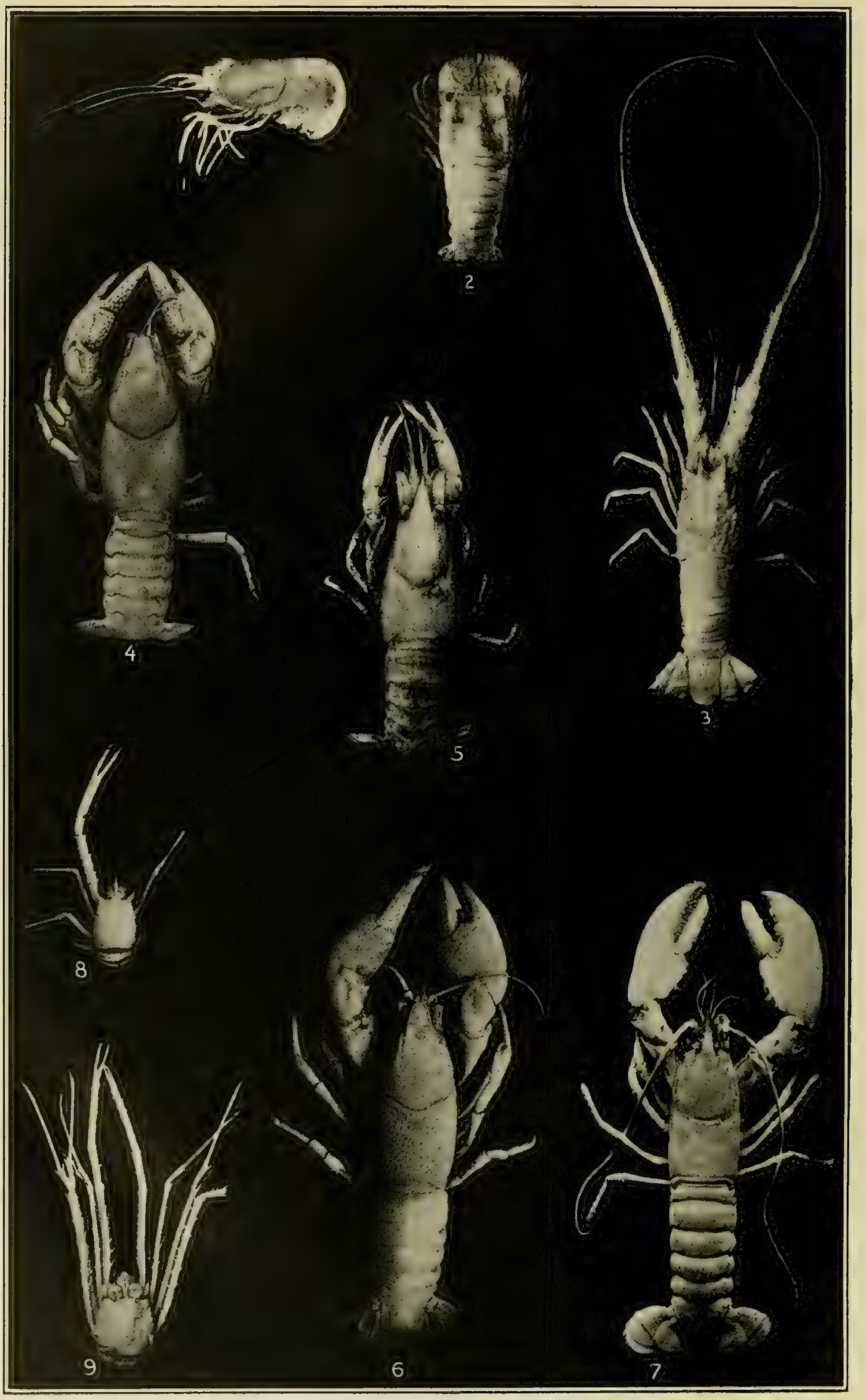
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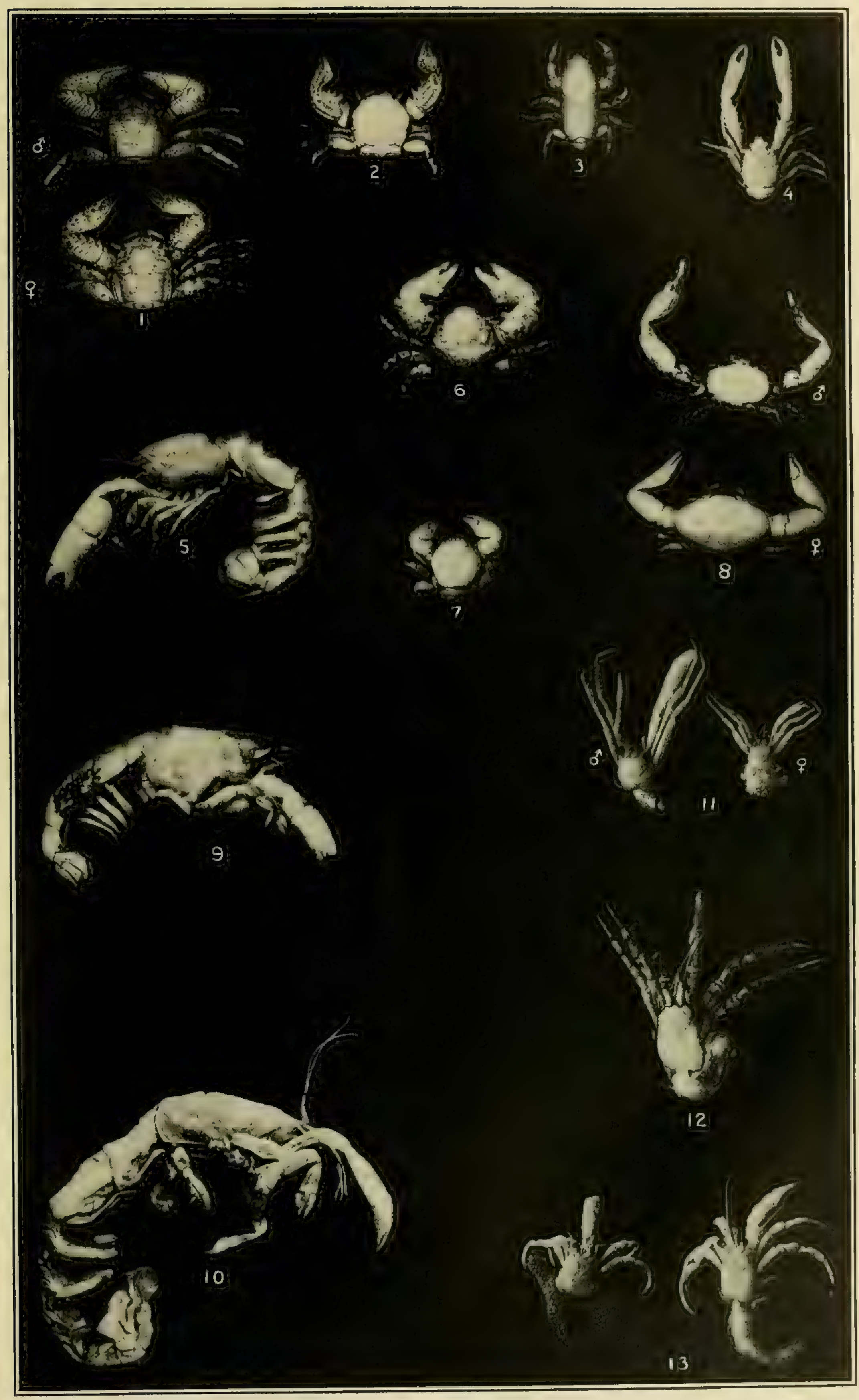
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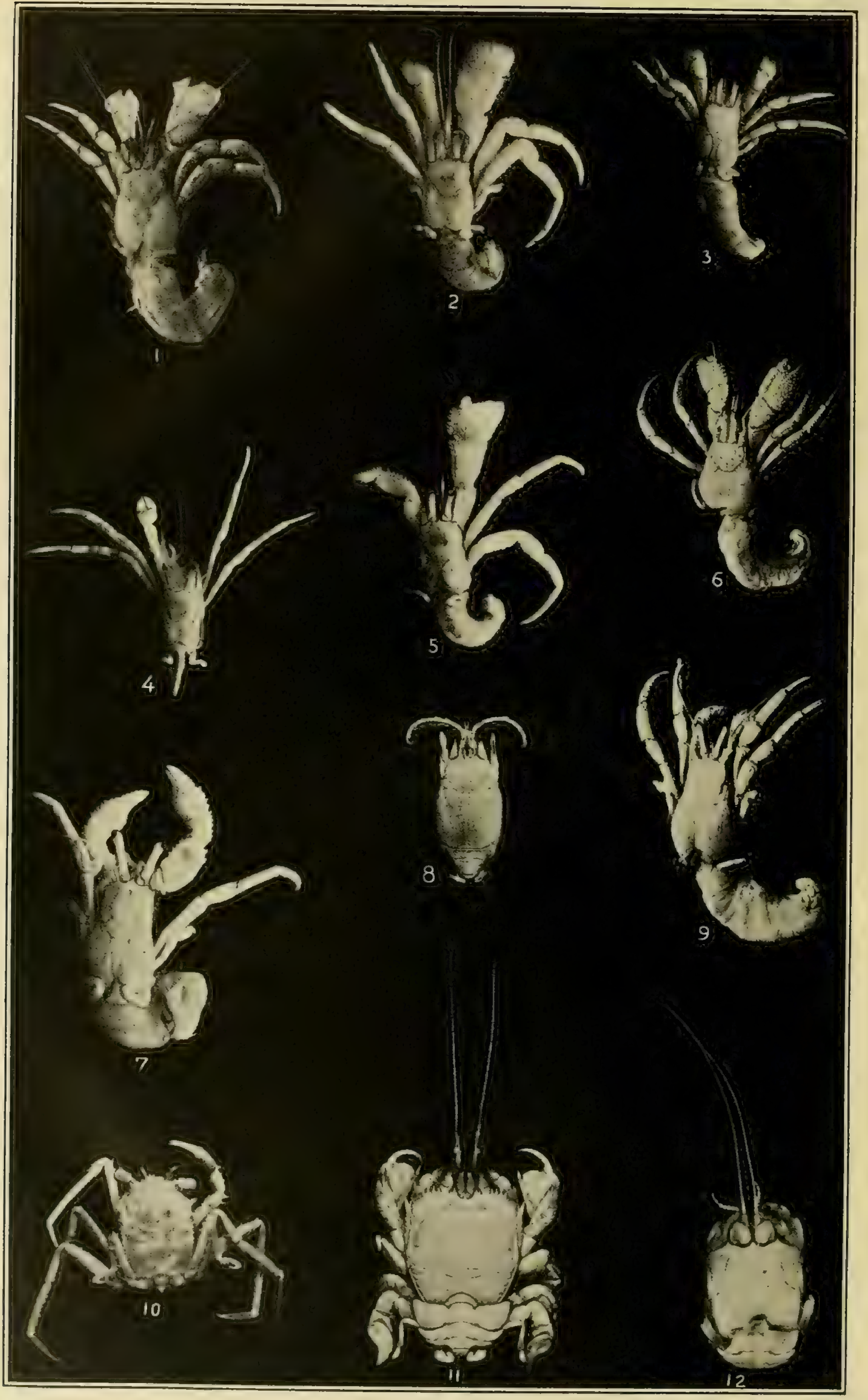
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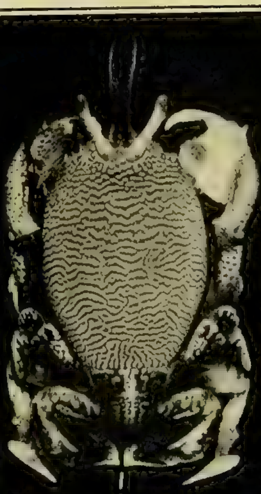

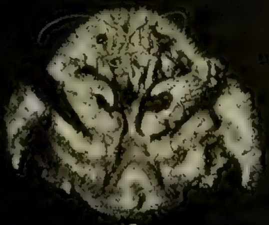

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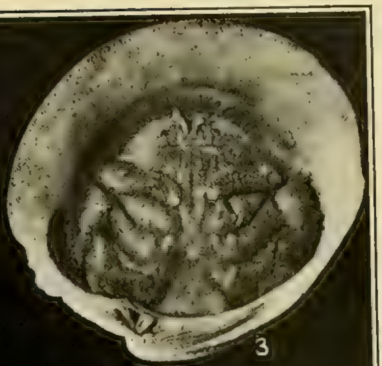

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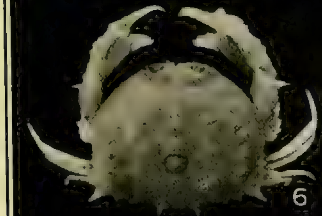

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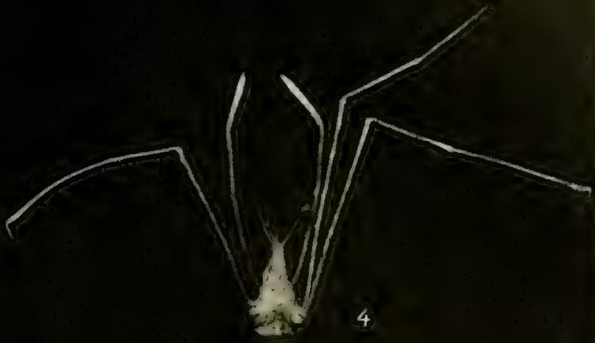

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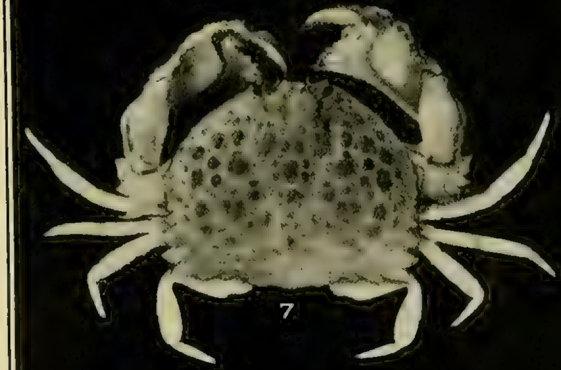

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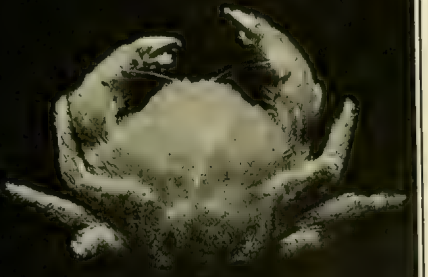

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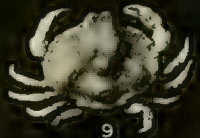

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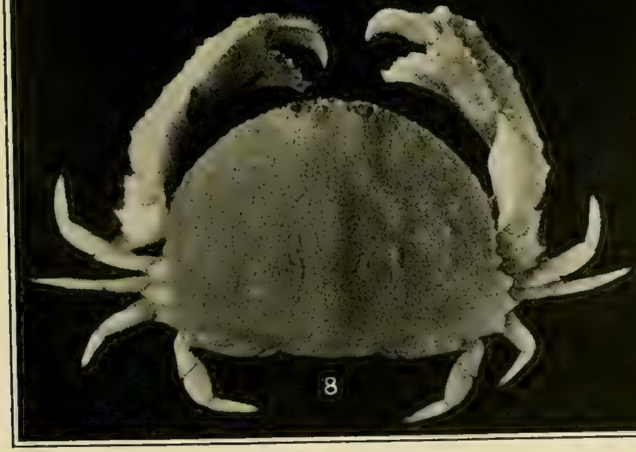

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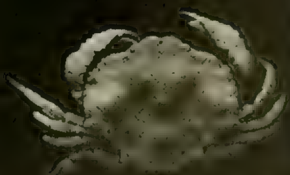

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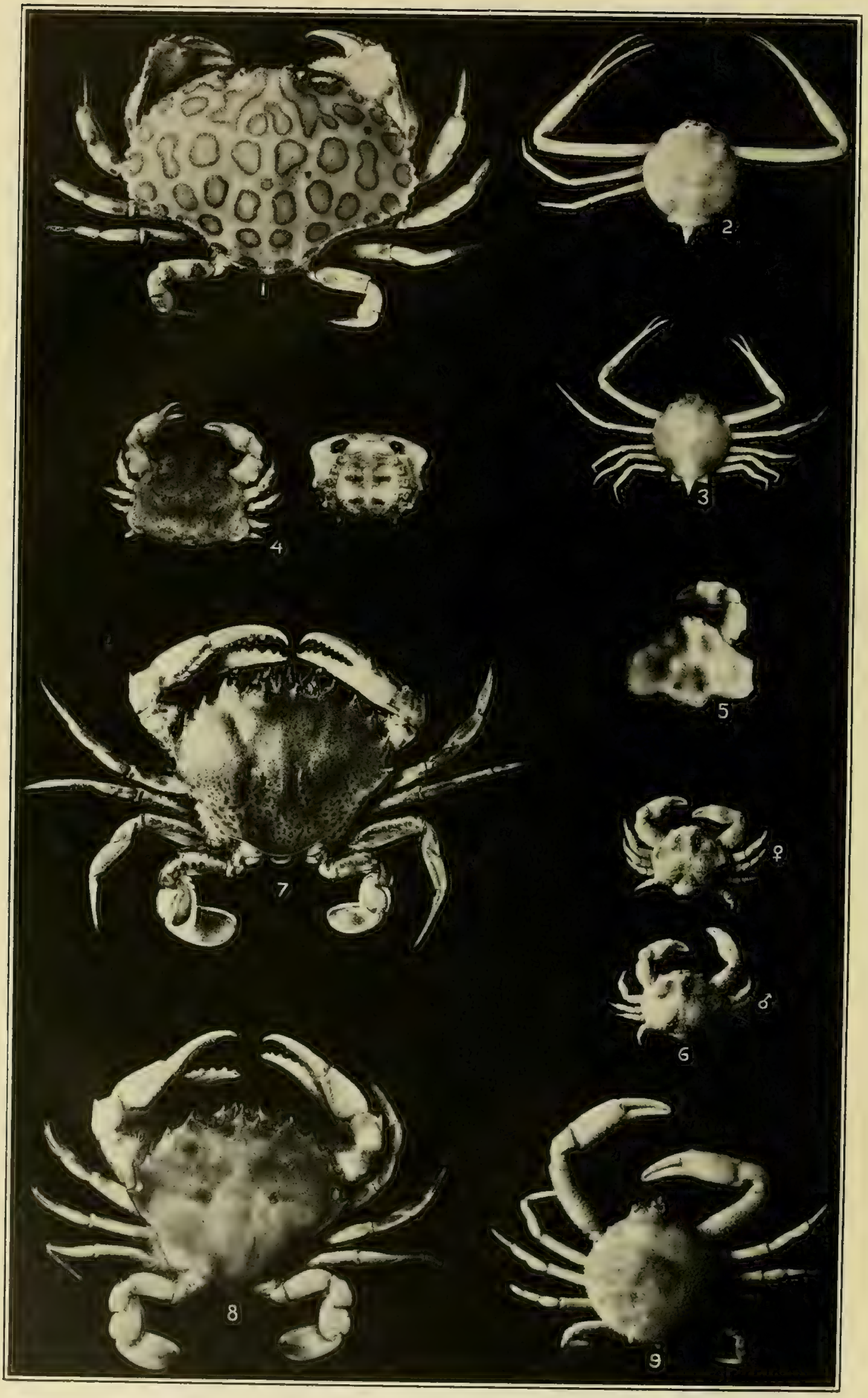
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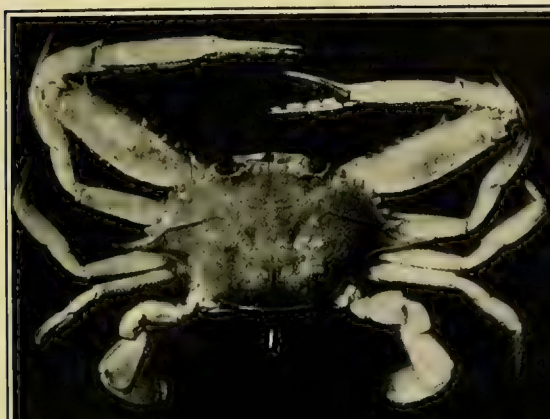
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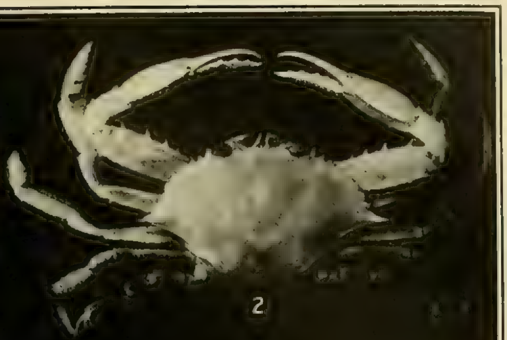
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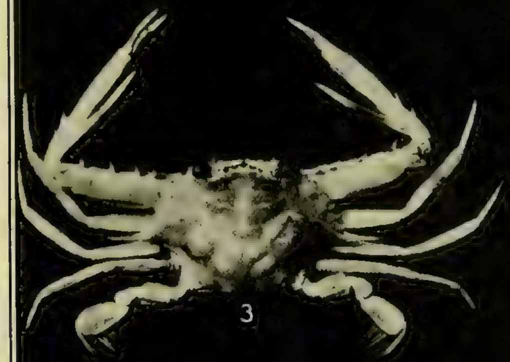
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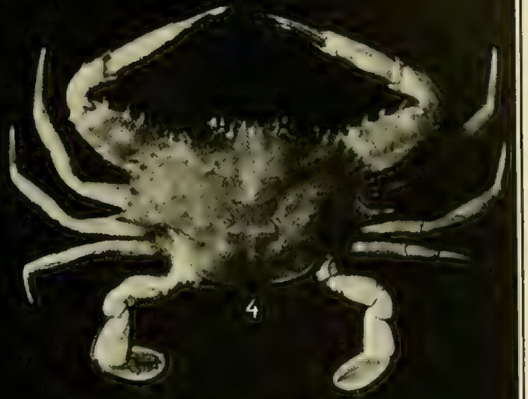
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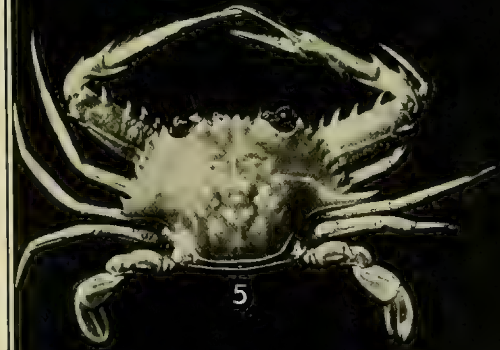
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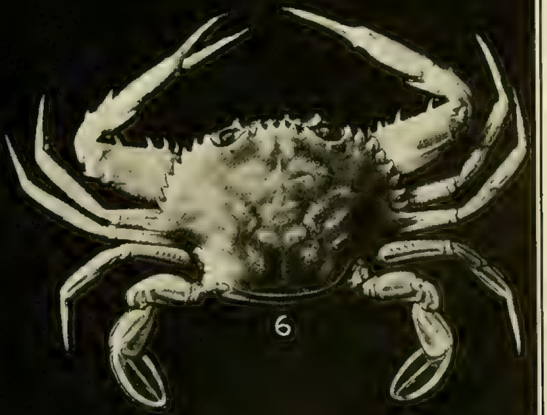
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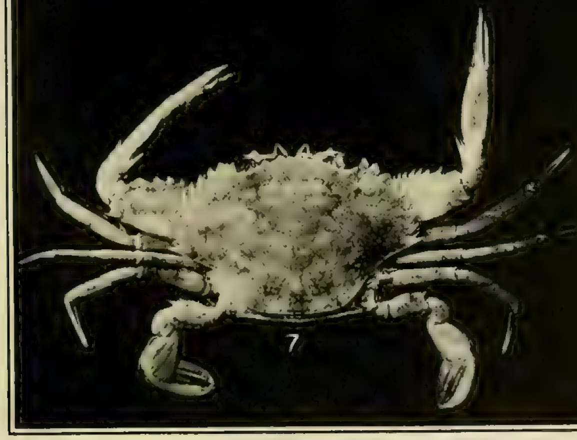
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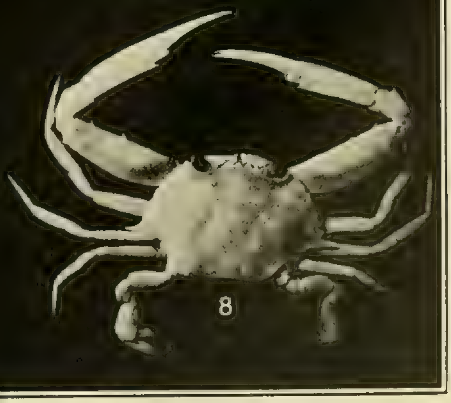
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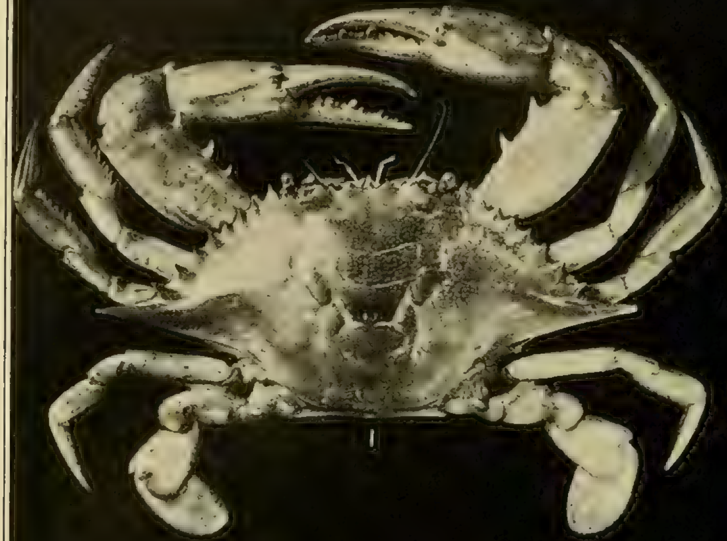
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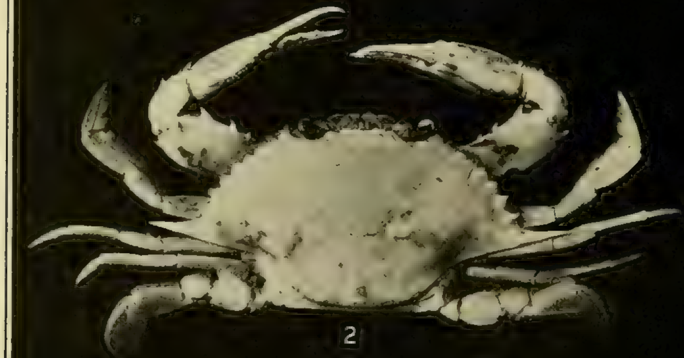
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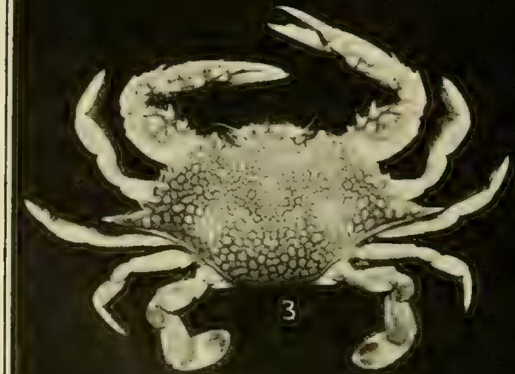
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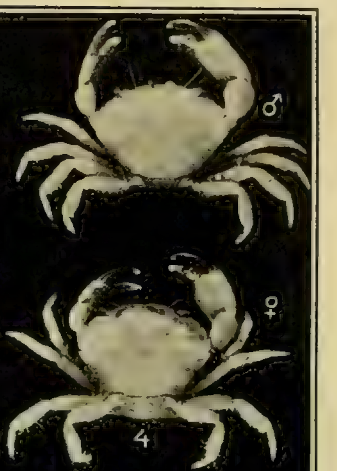

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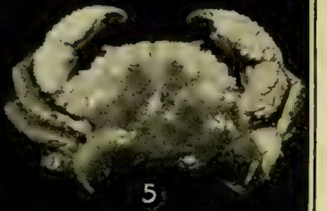
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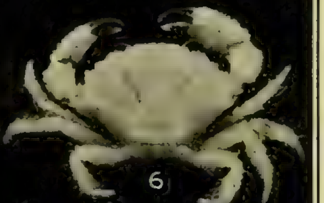
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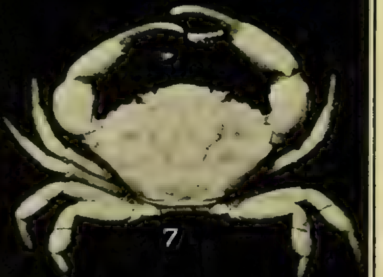
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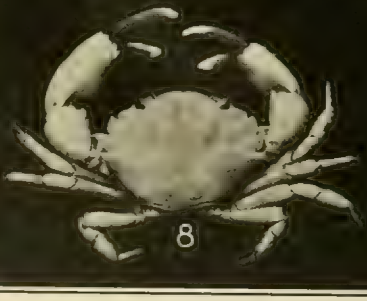
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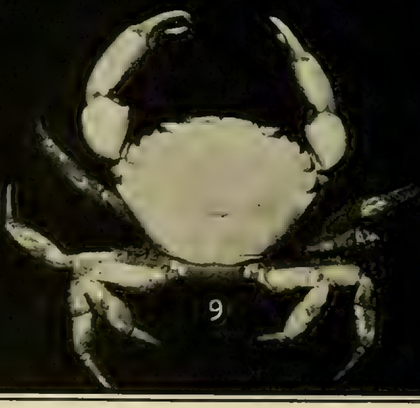
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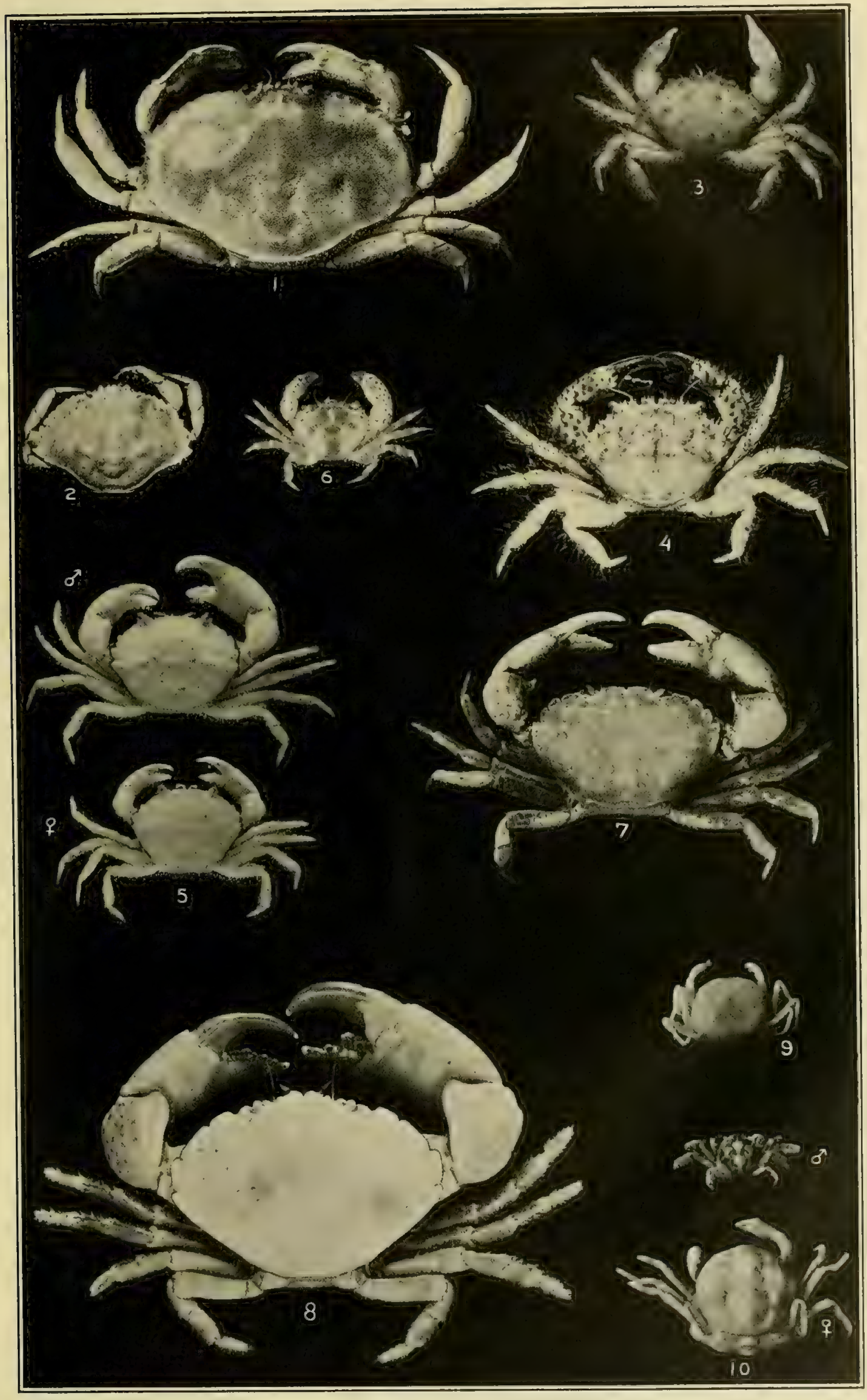
PLATE XXXV.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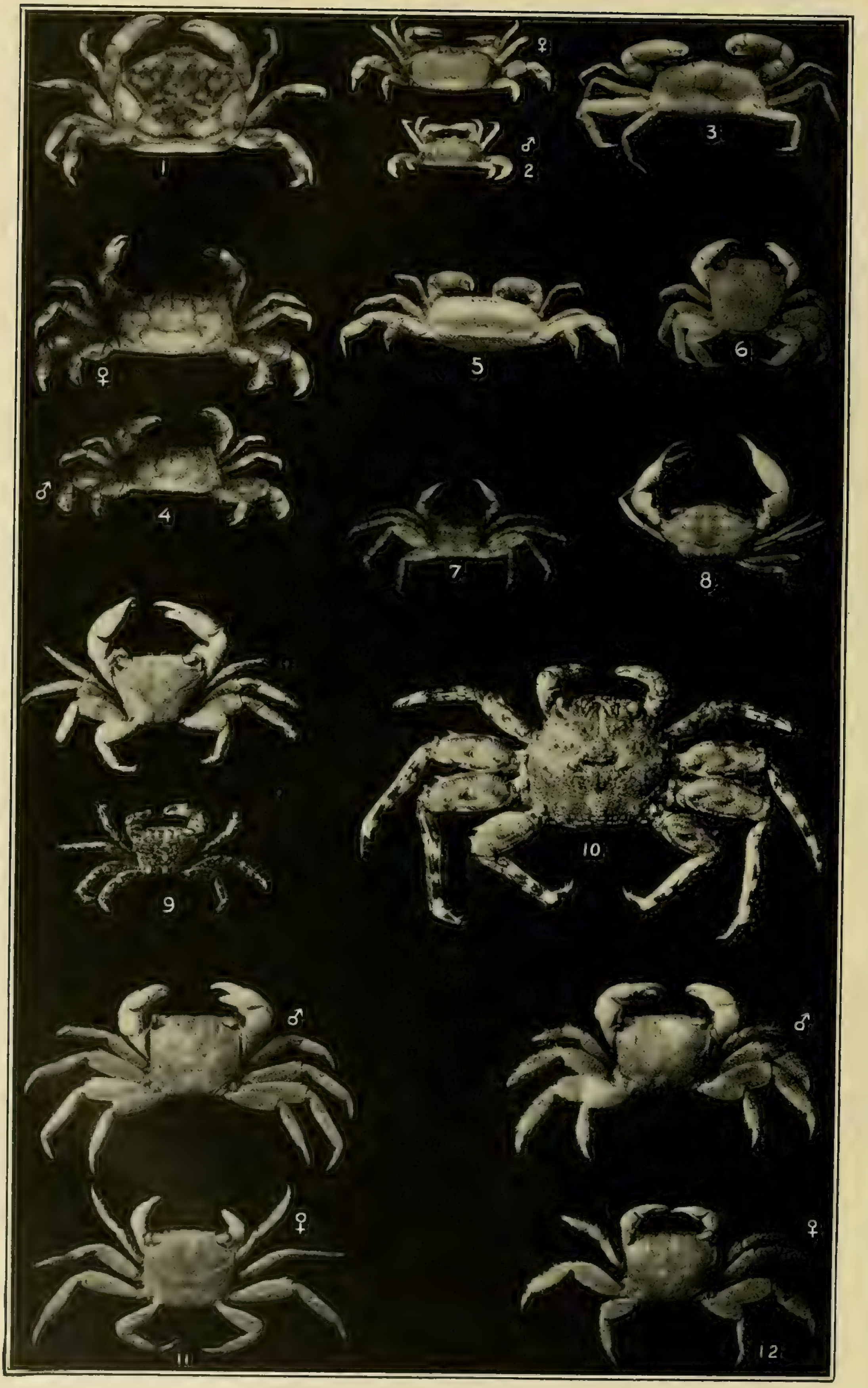
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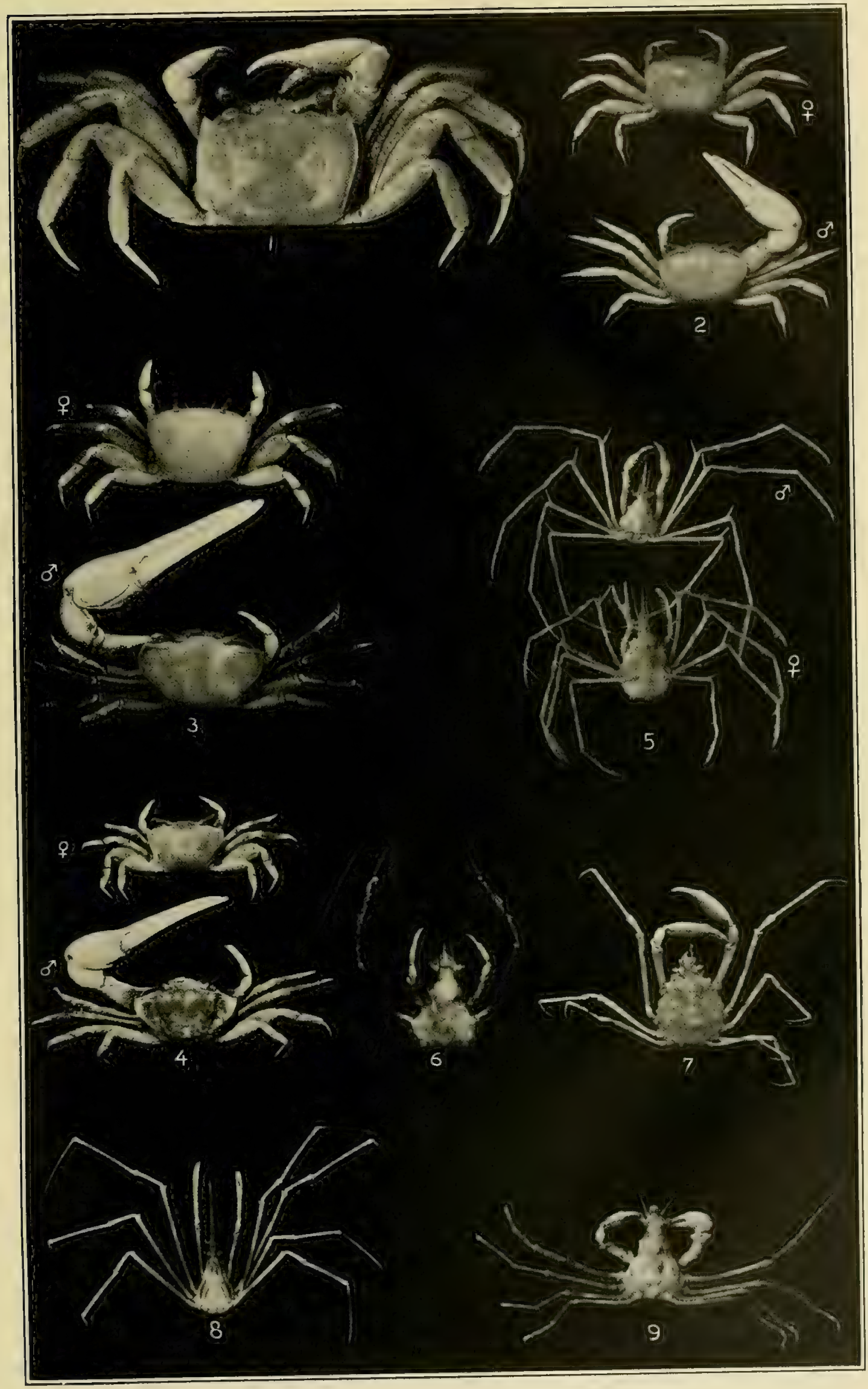
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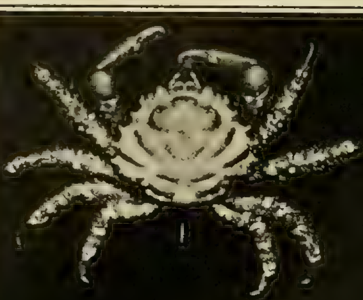
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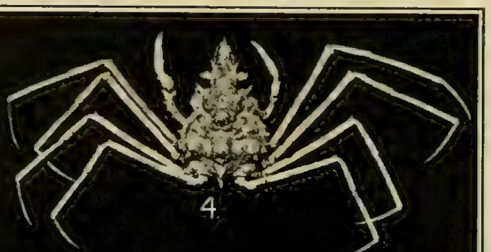
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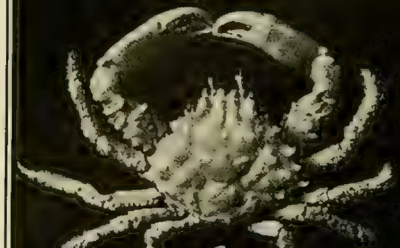
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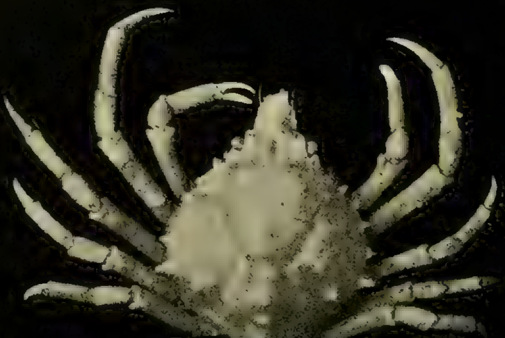
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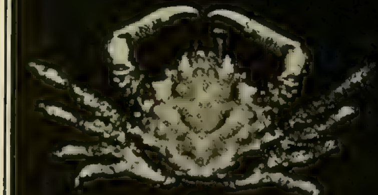
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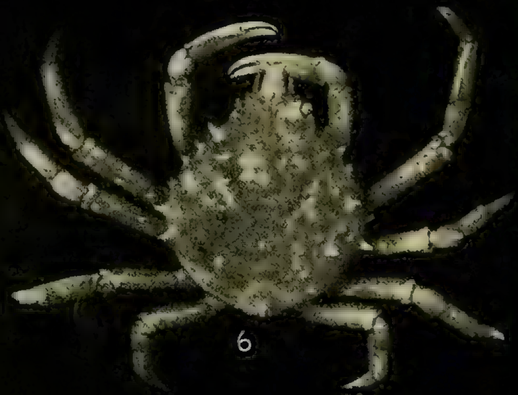
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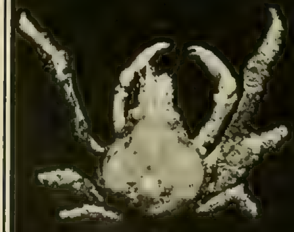
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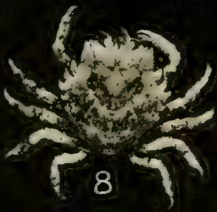
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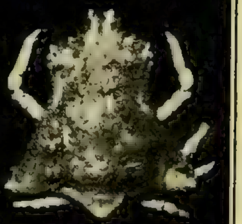
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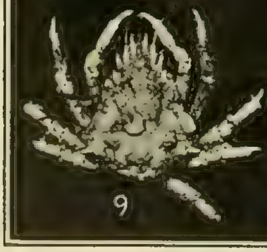
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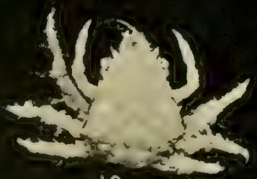
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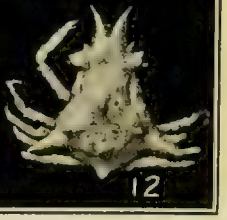
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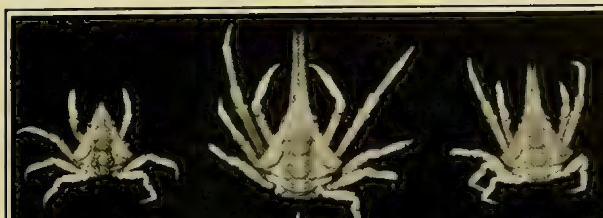

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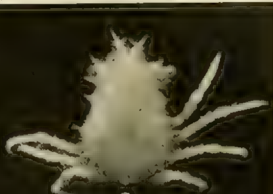

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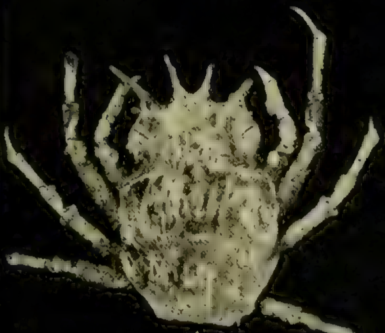

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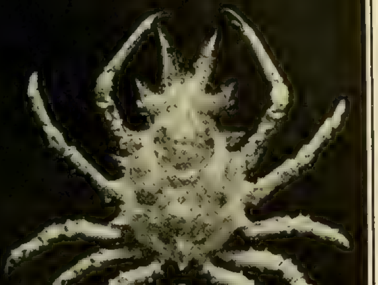

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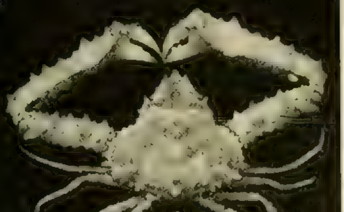

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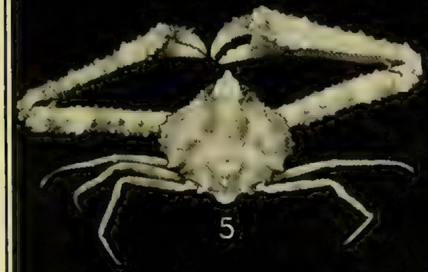

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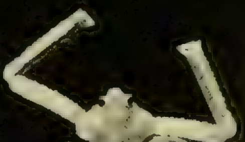

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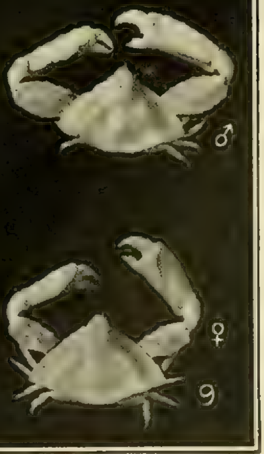

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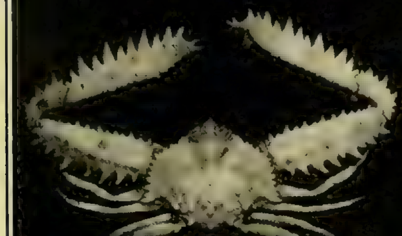

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NUTRITION OF OYSTERS: THE NATURE OF THE SO-CALLED "FATTENING" OF OYSTERS

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By Philip H. Mitchell

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Contribution from the United States Fisheries Biological Station, Woods Hole, Mass., and the Biological Laboratory of Brown University

NUTRITION OF OYSTERS: THE NATURE OF THE SO-CALLED "FATTENING" OF OYSTERS.

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INTRODUCTION.

The term "fat" as applied to oysters refers in a popular sense to their appearance. When in that condition the meats look plump and have in the body portions a milky appearance not unlike emulsified fat. The juice running out of the meats, however, shows the opalescence characteristic of glycogen solutions. This, together with the fact that glycogen is shown by analysis to be especially abundant in some specimens of oysters and to vary greatly in different specimens, suggest the possibility that glycogen may be the chief if not the only substance increased in oysters when they become "fat."

In a previous paper[a] it was shown that glycogen shows seasonal variations in oysters and that an increase of glycogen accompanies favorable feeding conditions. It was also shown that glycogen storage not only accompanied the normal feeding process, but could occur as the result of assimilation of sugar in solution in the water utilized by oysters.

This paper presents evidence in the form of chemical analyses[b] of oysters in varying nutritive conditions to show that the amount of glycogen present is the only material which marks a notable difference between "fat" and "lean" oysters.

VARIATIONS OF PROTEIN IN THE OYSTER COMPARED WITH THOSE OF GLYCOGEN.

The percentage of glycogen or protein in whole oyster meats is not a useful index as to their nutritive condition or their value as human food. The great variations in the proportion of water present in oysters are obvious causes of apparent variations in other constituents when figured as percentages. It goes almost without saying that the results of analyses must be expressed in terms of percentage of dry substance. An equally important variable is the salt content. Ash determinations made under comparable conditions have shown in these analyses variations from 14 to 37 per cent of the dried weight. It is therefore necessary in comparing determinations of glycogen, protein, etc., in oysters to express results in terms of percentage content of the ash-free solids. Glycogen and nitrogen, the latter to be used as an index of the amount of protein, were determined in many specimens of oysters of varying nutritive conditions. Some oysters were analyzed immediately after removal from their natural habitat, others after treatment in various artificial ways.

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[a] "Nutrition of oysters: Glycogen formation and storage," Bull. Bureau of Fisheries, vol. xxxv, 1915-16, pp. 151-161.

[b] Part of the analytical work presented in this paper was done by A. E. Barnard.

The results of a series of analyses are given in Table 1. The arrangement is in decreasing order of the amounts of glycogen in the ash-free solids.

TABLE 1.—COMPARISON OF THE GLYCOGEN AND NITROGEN CONTENT OF OYSTER MEATS.

Experiment No.	Dried meats.			Ash-free solids.		Experiment No.	Dried meats.			Ash-free solids.	
	Glycogen content.	Nitrogen content.	Ash content.	Glycogen content.	Nitrogen content.		Glycogen content.	Nitrogen content.	Ash content.	Glycogen content.	Nitrogen content.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	18.55	7.31	17.40	22.46	8.86	17	7.44	8.80	28.64	10.45	12.33
2	17.61	7.98	19.10	21.76	9.87	18	6.19	7.86	35.70	9.63	12.22
3	12.51	8.61	21.20	15.88	10.93	19	6.07	7.86	32.15	8.94	11.61
4	10.54	7.92	29.30	14.89	11.20	20	6.17	8.21	30.22	8.83	11.78
5	10.51	8.04	28.94	14.79	11.20	21	5.07	8.08	33.52	7.63	12.17
6	9.90	7.50	33.00	14.76	11.20	22	4.85	8.05	34.20	7.38	12.22
7	10.56	7.96	27.78	14.61	11.03	23	5.37	9.03	26.40	7.29	12.26
8	9.18	7.17	35.42	14.22	11.10	24	5.02	8.19	30.60	7.25	11.82
9	10.65	8.82	23.30	13.91	11.50	25	4.55	7.46	35.75	7.09	11.62
10	10.80	9.28	21.97	13.85	11.90	26	4.03	7.58	37.72	6.49	12.17
11	8.69	7.13	35.60	13.51	11.08	27	4.20	8.04	34.20	6.40	12.22
12	10.76	9.20	19.50	13.38	11.42	28	4.34	8.76	30.30	6.23	12.57
13	8.76	7.96	27.55	12.10	11.00	29	3.78	7.73	35.60	5.88	12.02
14	9.26	9.03	21.38	11.77	11.48	30	3.51	7.48	37.60	5.64	12.01
15	7.59	7.32	34.00	11.50	11.10	31	3.82	8.76	31.62	5.59	12.11
16	7.85	8.65	29.41	11.11	12.24	32	1.93	8.02	36.75	3.05	12.69

Examination of Table 1 shows that as the percentage of glycogen in the ash-free solids decreases the percentage of nitrogen, similarly computed, tends to increase. There is not a regular mathematical relationship between the two sets of figures, but many of the irregularities would fall within the limits of experimental errors. At any rate, the series shows strikingly that protein, as indicated by nitrogen determinations, does not increase in oysters as an accompaniment to glycogen storage.

In spite of their long continued growth, oysters, indeed, have some tendency toward nitrogen equilibrium. Like the higher animals, oysters not only store glycogen in preference to protein when food is plentiful, but also use glycogen to protect themselves from loss of body protein when food is scarce. Evidence of this is shown by a more detailed examination of some of the results recorded in this table. Eleven of these results are segregated in Table 2. They were selected because in each case previous experiments, recorded in the first paper[a] of this series, showed that changes in glycogen amounting to 10 per cent or more had occurred in periods from 2 to 14 days. The various abnormal feeding conditions causing these sudden fluctuations in glycogen content are explained in Table 2.

That the comparatively small variations in the nitrogen percentages in ash-free solids are merely due to the glycogen fluctuations can be seen from the computations of the percentage of nitrogen figured not only on an ash-free but also glycogen-free basis. These results are sufficiently uniform to show that sudden variations in the food supply of oysters are not accompanied by changes in their protein content.

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[a] "Nutrition of oysters: Glycogen formation and storage," Bull. Bureau of Fisheries, vol. XXXV, 1915–16, pp. 151–161.

TABLE 2.—COMPARISON OF GLYCOGEN AND NITROGEN OF OYSTERS WHICH SHOW SUDDEN CHANGES IN GLYCOGEN DUE TO ABNORMAL FEEDING CONDITIONS.

Experiment No.	Treatment.	Ash-free solids.		
		Glycogen content.	Nitrogen content.	Nitrogen in ash-free and glycogen-free solids.
		Per cent.	*Per cent.*	*Per cent.*
6	Fed dextrose	14.76	11.20	13.15
7	....do	14.61	11.03	12.94
8	Fed chopped seaweeds	14.22	11.10	12.95
9	Starved in filtered water	13.91	11.50	13.35
11	Starved in partly purified water	13.51	11.08	12.81
19	Fed dextrose	8.94	11.61	12.75
20	....do	8.83	11.78	12.92
21	....do	7.63	12.17	13.16
28	In polluted water 4 days	6.23	12.57	13.40
31	Changed from salt to fresh water	5.59	12.11	12.84
32	In polluted water 14 days	3.05	12.69	13.09

Changes in the proportion of protein present, aside from the uniform increase due to growth, no doubt occur in the oyster. An instance is shown by examination of certain of these results. Those in Table 3, chosen because they represent analyses made very soon after the oysters were taken from their natural habitat, show marked differences in their nitrogen content. This is true even when figured on a glycogen-free basis. That seasonal changes are responsible for this is indicated by the fact that oysters taken in July and August, which include the spawning season, tend to show a higher proportion of nitrogen than those taken in November. Further work would be required to give an adequate explanation of this, but the suggestion that accumulation of egg and sperm materials, together with heightened metabolism of reproductive glands, may be the explanation is obvious.

TABLE 3.—COMPARISON OF GLYCOGEN AND NITROGEN OF OYSTERS WHICH HAD NOT BEEN SUBJECTED TO ABNORMAL EXPERIMENTAL CONDITIONS.

Experiment No.	Date when taken from water.	Ash-free solids.			Experiment No.	Date when taken from water.	Ash-free solids.		
		Glycogen content.	Nitrogen content.	Nitrogen in ash-free and glycogen-free solids.			Glycogen content.	Nitrogen content.	Nitrogen in ash-free and glycogen-free solids.
		Per cent.	*Per cent.*	*Per cent.*			*Per cent.*	*Per cent.*	*Per cent.*
1	Nov. 15	22.52	8.86	11.46	25	July 27	7.09	11.62	12.54
2	Nov. 15	21.65	9.87	12.60	26	July 29	6.49	12.17	13.00
4	Aug. 20	14.89	11.20	13.17	27	July 19	6.40	12.24	13.08
16	Aug. 7	11.11	12.24	13.76	29	July 20	5.86	12.02	12.79
18	Aug. 10	9.63	12.22	13.53	30	July 22	5.64	12.00	12.72
22	July 7	7.29	12.22	13.17					

VARIATIONS OF FAT IN THE OYSTER COMPARED WITH THOSE OF GLYCOGEN.

The storage of fat in oysters, as detected by ether extraction of the dried meats, was also investigated. In the previous paper [a] the suggestion that fat might be formed from dextrose was tentatively made. It was based, however, on only two experiments and is not substantiated by the results of 13 analyses reported in Table 4 below. These later experiments were made with very careful technique. The oyster meats were dried at low temperature—some of them in vacuum desiccators—to constant weight and the ether used for extraction was rendered anhydrous by distillation over sodium immediately before use. The seeming increase of fat reported for one of the earlier experiments may have been due to the difficulty in maintaining ether in an anhydrous condition in the moist atmosphere of Woods Hole where the analysis was made. The results given in Table 4 do not show in the amounts of ether extract obtained any regularity or any relationship to glycogen. A number of other fat determinations on oysters have been made during the progress of this work. These are not included in this table because glycogen was not determined on the same specimens. In no case, however, did the ether extract amount to more than 3.50 per cent of the dried meats. A series of analyses reported by Atwater[a] gives higher figures, ranging from 6.50 to 10.97 per cent, with an average of 8.78 per cent for 34 analyses. As those determinations were not made with the use of anhydrous ether, they are hardly comparable with the ones reported in this investigation.

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[a] Bull., Bureau of Fisheries, vol. XXXV, 1915–16, pp. 155–161.

TABLE 4.—COMPARISON OF THE GLYCOGEN AND FAT CONTENT OF OYSTER MEATS.

Experiment No.	Glycogen in ash-free solids.	Fat (ether extract) in dried meats.	Fat in ash-free solids.	Experiment No.	Glycogen in ash-free solids.	Fat (ether extract) in dried meats.	Fat in ash-free solids.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	22.46	2.90	3.51	21	7.63	2.33	3.51
2	21.76	3.16	3.91	22	7.38	2.26	3.44
8	14.22	2.04	3.16	27	6.40	1.41	2.15
11	13.51	1.51	2.28	28	6.23	2.85	4.11
19	8.94	2.93	4.32	29	5.88	1.72	2.72
20	8.83	1.19	1.71	31	5.59	1.47	2.15
				34	9.20	1.70	2.60

The oysters showing the high glycogen content were the ones which presented a "fat" appearance. Indeed, the two specimens yielding the highest glycogen figures were selected for analysis by practical oystermen and chosen from beds of oysters deemed to be in the best marketable condition. The conclusion that glycogen is the real nature of the "fat" does not rest alone on the results recorded in the preceding tables. During the past two years glycogen determinations have been made on many samples of oysters in connection with this work. However, only those for which ash and either nitrogen or fat, or both, have been determined also are tabulated here. Of the other specimens it has been noticeable that the higher the glycogen the "fatter" the oysters appeared. Six samples from Lynnhaven Bay, Va., and Narragansett Bay, R. I., considered by the trade to be in good marketable condition, contained glycogen varying from 15.5 to 22.8 per cent of the dried weight and from 20 to 27.9 per cent of the ash-free solids.

DISTRIBUTION OF GLYCOGEN.

The distribution of glycogen in the bodies of oysters of average "fatness" was investigated. About 50 oysters were opened immediately after removal from the water, about September 15, when glycogen formation is rapid. All the juice was drained off from the shell contents and evaporated to dryness. The gills and mantles were dissected off from each meat, mixed together, dried, and ground. Similarly, the adductor muscle was separated and prepared. The remainder, or body, of the oyster containing the liver, digestive system, etc., was dried and ground into one preparation. Glycogen determinations on the four parts of the oyster thus obtained are reported in Table 5. These show little or no tendency for glycogen to diffuse out into the shell liquor of the oyster, and indicate that like higher animals oysters can store glycogen in all tissues but more especially in the liver, for the so-called liver is the chief organ in the part designated as the body of the oyster.

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[a] Atwater, W. O.: "The chemical composition and nutritive value of food fishes and aquatic invertebrates," Report of United States Commission of Fish and Fisheries, 1888, pp. 679–868.

TABLE 5.—DISTRIBUTION OF GLYCOGEN IN OYSTERS.

Parts.	Glycogen in dried substance.	Ash in dried substance.	Glycogen in ash-free solids.
	Per cent.	*Per cent.*	*Per cent.*
Body	27.60	12.71	31.61
Gills and mantles	12.69	18.31	15.53
Muscle	8.51	10.77	9.53
Oyster liquid	([a])	71.6	....

[a] Too low to be accurately determined.

CONCLUSIONS.

1. Protein and fat do not accumulate in oysters when they attain the condition known as "fat." This is in marked contrast to the accumulation of glycogen which must be regarded as the chief storage substance for oysters. "Fat" oysters are glycogen-rich oysters. Investigations and practical procedures looking to improvements in marketable value of oysters must take into account the importance of those nutritive conditions favoring glycogen formation.

2. The glycogen storage occurs more or less in all tissues of the oysters but is especially prominent in the region of the liver.

THE RANGELEY LAKES, MAINE; WITH SPECIAL REFERENCE TO THE HABITS OF THE FISHES, FISH CULTURE, AND ANGLING

By William Converse Kendall
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THE RANGELEY LAKES, MAINE; WITH SPECIAL REFERENCE TO THE HABITS OF THE FISHES, FISH CULTURE, AND ANGLING.

⁂

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⁂

INTRODUCTION.

This report is based primarily upon a biological and physical examination of Umbagog Lake during the summer of 1905 by a party detailed by the Bureau of Fisheries, under the immediate direction of the writer. During the summer of 1904 similar work had been conducted by the same party at the Connecticut Lakes in northern New Hampshire. The proximity of the Connecticut Lakes and their tributaries to some of the headwaters of the Androscoggin system, having a possibly significant bearing upon the local geographical distribution of the fishes, made it desirable to ascertain the faunal relationship. Umbagog Lake was selected as the particular field of operations owing to its geographical position and the fact that since the erection of Errol Dam it is the final reservoir of the entire headwaters of the Androscoggin River. Umbagog is not a representative lake, as its physical conditions, both natural and those brought about by artificial modifications, are far different from any of the other lakes in the system. It is, however, in many respects a peculiar one, and, owing to the peculiarities, offered an attractive subject for faunal study, both by itself and in its relation to the rest of the Rangeley chain of lakes.

A thorough biological survey of the whole upper Androscoggin system, or even of the lakes of the principal chain, would have afforded a more valuable contribution to science and fish culture, but it would have entailed more time and a larger party than were available.

Although the remainder of the chain received no special study by the party, the writer, in previous years, had opportunity for making observations therein, especially upon the fishes, and it has been possible to obtain much information from other sources. The accompanying descriptions of the lakes and their physical conditions are mainly adapted from the first and second reports of the Maine Water Storage Commission for 1910 and 1911, respectively. The appended maps are somewhat modified copies of those made by the water-resource branch of the United States Geological Survey in cooperation with the Maine Water Storage Commission.

This report is mainly concerned with the present condition of the fish fauna of the lakes as affected by the modified physical conditions and the introduction of various nonindigenous species and the possible bearings upon the maintenance of the fishing in those waters and fish culture and fish-cultural distribution in general. This involves not only an analysis of the data concerning the habits and local distribution of the fishes and their relation to their environment, gathered during the investigation and desultory observations, but a consideration of the history of angling and fish culture in those waters.

LOCAL GEOGRAPHY AND PHYSICAL FEATURES OF THE RANGELEY LAKES SYSTEM.

The Rangeley Lakes lie in the western part of Maine, just below the forty-fifth parallel of latitude; in fact, Cupsuptic Lake, at present a northern arm of Lower Rangeley, or Mooselucmaguntic Lake, just impinges on that parallel. The general trend or flow of the lakes is southwestward, discharging their waters into the Androscoggin River. There are five large lakes in the chain, having an area of 64.59 square miles. The entire drainage area, exclusive of that of the Magalloway River, is 635 square miles, making the area drained by the Androscoggin at Errol Dam, the lowest of the storage dams, situated about 5 miles below Umbagog Lake, 1,095 square miles. The total storage of these five lakes is 21,357,358,000 cubic feet. They have an average elevation above sea level of about 1,420 feet at high-water line.

The Rangeley series comprises four, or, as sometimes denominated, 5, large lakes, which are not upon the same level, as shown by the following statement:

	Feet (high-water line) above sea level.
Oquossoc, or Upper Rangeley Lake	1, 517
Mooselucmaguntic, or Lower Rangeley Lake	1, 467. 41
Molechunkamunk, or Upper Richardson Lake	1, 448. 9
Wellekennebacook, or Lower Richardson Lake	1, 448. 9
Umbagog Lake	1, 246. 3

Cupsuptic Lake is practically a portion of Mooselucmaguntic, and Molechunkamunk and Wellekennebacook really compose one body of water between the outlet of Mooselucmaguntic and Middle Dam. A narrowing in the lake gives rise to the popular designation of the two expansions as separate lakes.

The surrounding country is mainly hilly, and, excepting immediately about Umbagog and Upper Rangeley Lakes, is principally a vast forest, which has been more or less modified by many years of lumbering operations and, to some extent, by forest fires. Lumbering operations are still extensively carried on, with somewhat different objects and certainly by different methods from those of olden times. The lakes and streams have also been modified both for lumbering and milling purposes, and the lakes now form the principal storage reservoir for the great mills all along the Androscoggin, particularly at Berlin, N. H., Rumford Falls, Livermore Falls, Auburn, Lewiston, and Brunswick, Me.

Such modification of the physical conditions could not fail to have had effect in one way or another on the fauna of the lakes. Changes in the level of the lakes necessarily would tend to change the feeding and breeding places of the fishes, and dams interfere with their migration from one lake to another.

Wells stated in 1869 that there were four dams in the Rangeley chain—one at the foot of Rangeley (Oquossoc), 10 feet high with 4-foot head of water; one, Upper Dam, at the foot of Lower Rangeley (Mooselucmaguntic), 20 feet high with 14-foot head; one, Middle Dam, at the foot of Richardson (Wellekennebacook), 16 feet high with 12-foot head; and one on the Androscoggin below the mouth of the Magalloway, at Errol, 14 feet high with 14-foot head. The present dams are mentioned in connection with the individual lakes controlled by them.

There is much outlying or tributary water composed of lakes and streams, some of which are of considerable size. Some of the ultimate headwaters of these Rangeley Lakes affluents are in close proximity to the headwaters of other river systems, as the Connecticut, St. Lawrence, and Kennebec, but doubtless in most, if not all, instances there are topographical barriers to the interpassage of fishes.

There are no available data as to when the lakes begin to freeze or which freezes first. The time of freezing depends greatly upon the season, and probably the smaller bodies of water will be completely frozen first. The time of the breaking up and clearing of the lakes varies also with the season.

The phenomenon of the clearing of the lakes of ice is usually referred to as "going out." One says, "The ice has gone out of the lakes," as though it had at some particular time left by the way of the outlet. As a matter of fact, its departure is mainly by the reverse process of its coming; the melting process, however, is aided by winds and waves, which drive the ice about and dash it against the shores.

The depth to which the lakes freeze depends upon the weather conditions, but the Rangeleys oftentimes freeze at least 3 feet. On April 7, 1893, it was reported that the ice was 28 inches thick, all solid blue ice; about the middle of March, 1895, it was said to be fully 3 feet thick, one-half of which was solid blue ice and the rest snow ice; and on April 19, of the same year, it was stated that the ice was 22 inches thick.

The following statement shows the dates of the clearing of the lakes from 1875 to 1915, inclusive:

1875	May 28	1889	Apr. 29	1903	Apr. 29
1876	May 26	1890	May 9	1904	May 1
1877	May 6	1891	May 14	1905	May 2
1878	Apr. 26	1892	May 9	1906	May 13
1879	—	1893	May 21	1907	May 19
1880	May 8	1894	May 2	1908	May 10
1881	May 15	1895	May 7	1909	May 14
1882	May 21	1896	May 9	1910	Apr. 19
1883	May 14	1897	May 12	1911	May 13
1884	May 11	1898	May 6	1912	May 3
1885	May 16	1899	May 7	1913	May 4
1886	May 5	1900	May 15	1914	May 18
1887	May 20	1901	May 4	1915	Apr. 29
1888	May 23	1902	Apr. 28		

OQUOSSOC LAKE.

Oquossoc or Rangeley Lake proper, sometimes called Upper Rangeley Lake, is the uppermost of the series. It is generally but irregularly rhomboidal in shape but with long coves at each angle—Rangeley Cove at the northeast, Greenvale Cove at the southeast, Outlet Cove at the northwest, and South Bog Cove at the southwest. The other principal coves, named in order from the eastward, are Hunter and Smith Coves on the north and South and Little South Coves on the south. The islands are few in number, principally Dicksons, northwestward of Greenvale Cove, and South Bog Islands at the entrance of South Bog Cove.

Oquossoc Lake is about 5⅓ miles in a direct line in its long axis from the east to west end. The Greenvale and Outlet Coves are the longest two, each about 1½ miles, making the extreme length of the lake approximately a little over 8 miles. Its greatest width directly north from just east of South Cove is nearly 2 miles, and the narrowest place at right angles to the east and west axis is about four-fifths of a mile, northward from Long Point to just west of Mingo Springs; that is, about 1¾ miles from the west end of the lake. The Maine Water Storage Commission gives its average high-water elevation above the sea as 1,577.2 feet and its area as 9.76 square miles. The greatest depth, 145 feet, is in the upper end, about three-fourths of a mile northward and westward from Greenvale Cove or directly north by compass from Haines Point, the western limit of Greenvale Cove. Greenvale Cove is 60 to 94 feet deep near its entrance, shoaling gradually to the head of the cove. South Bog Cove carries 14 to 30 feet in its deepest water. The mid lake carries from 50 to over 100 feet as far west, at least, as a line northward from South Bog Islands. Thence it shoals irregularly northwestward to the outlet.

The storage is controlled by a crib dam of the open-weir type, over which the water seldom, if ever, flows. The right-hand half of the dam is occupied by the usual log sluicing gates, housed over. The elevation of the sill is 60.65 feet above the sill of the dam at the foot of Mooselucmaguntic Lake, giving the outlet, Rangeley stream, a considerable current in its 2.6 miles course to the lake below. The stored water of this lake, some 2,584,328,000 cubic feet, is usually the last to be drawn upon, and hence high level is usually maintained through the summer tourist season.

The principal tributary waters are as follows: Northeast of Rangeley Village is Gull Pond, having an area of 0.75 square mile and being about 1¼ miles long by five-eighths of a mile wide, which discharges its water into Haleys Pond through a stream about three-fourths of a mile in length. Haleys Pond is approximately three-fourths by one-half of a mile in its greatest diameter and has a depth of 7 to 17 feet, the deepest water being at the upper end. It is separated from Oquossoc Lake by a dam and short stream only, which empty into Rangeley Cove. The northern affluents are: Round Pond, about one-half by less than one-fourth of a mile, connected by a short stream with Dodge Pond, which is 1⅛ miles long by a little over one-fourth of a mile wide and empties into Hunter Cove through Dodge, or Collins Brook, something over 1 mile in length. The deepest water of Dodge Pond is at the outlet end, where it is 40 feet, but it carries a depth of 35 feet to near the upper end. About one-fourth of a mile from Dodge Pond another stream from Quimby Pond joins Dodge Brook. Quimby Pond, with an area of 0.27 square mile, is about three-fourths by one-half of a mile in extreme diameters and its outlet about 1½ miles in length. There are several other brooks from diminutive ponds or none on the north shore, but they are of no consequence so far as this report is concerned. Flowing into the extreme end of Greenvale Cove is Niles Brook from the eastward and Long Pond Brook, conveying the waters of Long Pond and its tributary brooks. Long Pond is about 1⅞ miles long and three-fourths of a mile in its southern diameter. The distance from Long Pond to the lake by the outlet is about 1⅞ miles. There are several brooks tributary to Long Pond, one of which comes from a small pond something over 2½ miles to the southwestward, and Long Pond is not over one-half of a mile in a direct line from the headwaters of a branch of Sandy River, a tributary of the Kennebec. Several minor brooks empty into the lake on its southern shore between Greenvale Cove and South Bog Cove. At the southern end of South Bog Cove, South Bog Brook, some 5 miles or more in length, discharges the waters of Mountain and Beaver Ponds. Mountain Pond is about one-half of a mile long and somewhat less than one-fourth of a mile wide. Its outlet is over 1½ miles long, with a considerable pondlike expansion in its course, and joins the outlet of Beaver Pond about three-fourths of a mile below the latter pond, to form South Bog Brook. Beaver Pond is about five-eighths of a mile long and one-fourth of a mile wide. Various small brooks enter the lake between South Bog Cove and the outlet. The chief importance of many of them, and it is of considerable importance to the lake, is that they afford shelter or nurseries, as it were, for young trout.

The permanent village of Rangeley is situated on Rangeley Cove, the terminus of the Sandy River and Rangeley Lake Railroad. There are numerous summer hotels, public camps, and private summer residences, especially at the east end, along the north shore and east end of the lake. About three-fourths of a mile from the outlet is the comparatively recent village of Oquossoc, reached by the Rumford Falls and Rangeley Lake branch of the Maine Central Railroad.

MOOSELUCMAGUNTIC LAKE.

This lake, sometimes referred to as Lower Rangeley and the Big Lake, is the largest of the Rangeley chain. The upper part of Mooselucmaguntic now floods what was formerly Cupsuptic Lake and extends from Cupsuptic River down about 4¼ miles to a narrow part of the lake, or just below the combined mouth of Kennebago and Rangeley Streams. From Cupsuptic River to Upper Dam the distance is between 11 and 12 miles; from the same stream to Bemis, about 16 miles; and from Bemis to Upper Dam, about 7 miles. Before the lake was raised to its present level the separation between the two lakes was much more marked than at present. The upper part runs in a direction a little east of south and with irregular shores and deep bays.

Mooselucmaguntic proper begins at the lower end of Cupsuptic Lake, about half a mile above Haines Landing, not far from the village of Oquossoc, previously mentioned, and runs almost due south for a little over 5 miles to Students Island. At the upper portion it is about a mile wide, but gradually broadens to the widest part of the lake about 3⅖ miles from the entrance to Cupsuptic Lake. The direct east and west line from the head of Bugle Cove to the opposite shore is 3⅗ miles, but in a northwesterly direction to a point at the head of a small cove, just east of Wildwood Camps, it is about 4⅒ miles. From the first line mentioned it narrows again to a line crossing Students Island in a southeasterly direction from Brandy Point, which is on the west shore of the lake, 5 miles from Haines Landing. Here the lake takes a northwest direction, extending from the end of a cove near Bemis to the head of a cove on the southerly side of Brandy Point. This portion is of fairly uniform width except in the coves mentioned, the widest part being at the Bemis end just southeast of Toothakers Island, where it is 2⅒ miles across. From Brandy Point to a point on the southwest shore at the entrance to the outlet cove it is about 1½ miles. From the latter point to Upper Dam, at the foot of Mooselucmaguntic Lake, it is just 1 mile. The narrows at the entrance of Cupsuptic Lake are about one-half of a mile across, and it is about three-fifths of a mile across to a point northwest of Haines Landing. The distance between Students Island and Brandy Point is seven-tenths of a mile, and Students Island, four-fifths of a mile long and half as wide in its broadest diameter, is one-fifth of a mile at its southeast end from the east shore or broad cape south of Bugle Cove.

The other important island of the lake is Toothakers, previously referred to, the northwest end of which is slightly over 1 mile from Students Island and the southeast end about 1½ miles from Bemis Station. It is irregularly elliptical in shape, about 1⅘ miles long by nearly four-fifths of a mile wide in its greatest diameters.

Pleasant Islands, famous as the location of a sportsmen's camp and unimportant for any other reason, are situated about 3 miles in a direct line up Cupsuptic Lake from Haines Landing. A group of small islands, known as Browns Islands, just above the entrance to Cupsuptic Lake, are nearly 1½ miles from Haines Landing. There are other small islands in Mooselucmaguntic Lake, particularly in Wildwood Camps Cove and the cove just north of it. At a number of places shoals occur, where the depth is only a few feet at high water and which appear as islands at low water.

The altitude of Mooselucmaguntic at high water is 1,472.4 feet, and its area, including Cupsuptic Lake, is 28.27 square miles.

On the east and west portions of the lake the deepest part is found south from the west end of Students Island, where it is 100 feet. The average depth for quite an area is probably about 50 feet. East of Toothakers Island the maximum depth is from 30 to 35 feet, and the deepest part of the lake is in Bugle Cove, where a depth of 124 feet is found about 2$\frac{1}{10}$ miles northeastward of the northwest end of Students Island. Cupsuptic Lake is very shallow above Pleasant Islands, but below this point the deeper waters carry 50 and 60 feet.

Upper Dam at the outlet, the height of which during the last 10 years or so has been increased to the level of the land on the south shore of the lake, controls the storage of the lake, giving it at high water 10,002,039,000 cubic feet. The dam is about 200 feet between abutments. A dike extends from each abutment to the higher land beyond; that in the southeast being nearly a mile in length, mostly of artificial construction. The sill of the dam is 18.03 feet above that of Middle Dam at the foot of Wellekennebacook. The original bar that formed the dam for the natural lake is about one-half mile above the present dam, and if the gates at the dam are opened a sufficient amount the water in the pool between this bar and the dam is drawn down to a point below the water in the lake.

The shores are irregular, with points and bays both large and small. The greater part of the shore is covered with driftwood and "dry khi," in some of the low places for one-fourth of a mile. This is particularly true of the portion about Cupsuptic Lake. The greater part of the shore line is wooded, being covered with second-growth timber, both hard and soft.

There is but little lowland bordering the lake, this being found at the eastern extremity near Bemis Stream and a small area near Upper Dam. There is also lowland on the east around the entrance of Kennebago and Rangeley Streams and at the upper end of Cupsuptic Lake. With the exception of these low places the land gradually rises, the 5-foot contour being from 50 to 100 feet back, on the average, and the 10-foot contour about 150 feet.

The principal tributaries of Mooselucmaguntic Lake are Cupsuptic and Kennebago Rivers and Rangeley Stream in the northern part of the lake and Bemis Brook at the southern end. There are a number of other small brooks flowing into the lake at various places.

Cupsuptic Pond is a small body of 0.30 square mile area at the extreme headwaters of Cupsuptic River near the boundary line between Maine and Quebec. Cupsuptic River, receiving many branches in its course, some of which rise in the Boundary Mountains, flows southward through three townships, or about 17 miles in a direct line, to Cupsuptic Lake. Cupsuptic Pond is not far from the head of the lower east branch of the main inlet of Parmacheenee Lake, but a rather large mountain intervenes. Parmacheenee Lake is only about 4 miles in a direct line from the Cupsuptic River, but the intervening country is mountainous.

Kennebago River has its extreme source in the Seven Ponds, the larger of the group being in township 3, range 5. The principal pond, shown on the maps as Big Island Pond, of 1.20 square miles area, is in the northeast corner of the township. It flows into Long Pond, or the Straits, situated in about the center of the township. Into Long Pond several tributary streams from other ponds converge. The extreme headwaters of some of these streams are in close proximity to the headwaters of Arnold River, which flows into Lake Megantic in the Province of Quebec and is a tributary of the St. Lawrence River. The Boundary Mountains form a separation. Another of the branches heads in a small pond not over three-fourths of a mile in a direct line from a small pond in the extreme headwaters of Dead River, a tributary of the Kennebec system. There is naturally a topographical division between the two waters, but it is not nearly so marked as in the Boundary Mountains. Long Pond, or the Straits, is approximately 18 miles in a straight course to the junction of the Kennebago River and Rangeley Stream. Kennebago River flows very irregularly in a southward direction and in its lower portion is especially sinuous. About 10 miles directly northward of the junction with Rangeley Stream is Kennebago Lake, situated a little to the left of and connected with the Kennebago River by a short outlet. Little Kennebago Lake is not far north of this in the course of the river and has an area of 0.26 square mile.

Kennebago Lake is situated mainly in Township 3, range 3. It is stated that the distance from the dam at the outlet to Indian Rock at the mouth of Kennebago River is 12.3 miles, and the elevation of the lake at average low water is 1,774 feet, or 327.7 feet above the sill of the gate at Upper Dam. The lake is approximately 4½ miles long, with a greatest width of less than 1 mile. Its area is stated by the Maine Water Storage Commission report to be 2.74 square miles at low water, and 4.13 square miles at high-water line. In most of its extent the lake carries 20 to 50 feet close to low-water line, and in the deeper portions 60 to over 100 feet, having a storage capacity at low water of 350,828,000 gallons. The lake lies approximately in a southeasterly and northwesterly direction. In the southeastern half the shores are mainly comparatively high and the water bold; in the other half there is considerable low land that is flooded at high water, and even Little Kennebago Lake is flooded out by the high water of this lake.

Bemis Brook rises from two branches, one of which heads in Four Ponds. The largest and lowermost of the ponds is about 2½ miles in a direct line from Bemis at the southern end of Mooselucmaguntic Lake. Four Ponds, as is also the head of the other branch of Bemis Brook, are very close to headwaters of branches of Swift River, a tributary of the Androscoggin, and a pond at the head of Swift River, is shown on the maps as not over one-half of a mile distant from a pond at the head of a branch of Sandy River, but in a very hilly country.

RICHARDSON LAKES.

These lakes are practically one body of water consisting of two expansions connected by The Narrows.

Upper Richardson.—The main inlet is the outlet of Mooselucmaguntic Lake, which enters Upper Richardson or Molechunkamunk Lake a little north of midway of its eastern side. Molechunkamunk is about 6⅘ miles in length and not over 1 mile in greatest width. The lake is somewhat crescentic in shape, the convexity being toward the east. The shores are more or less irregular in outline and comparatively low in most places. The principal coves are West Arm, at the west side of the north end of the lake, and Half Moon Cove, on the west side of the lake about 3⅕ miles south of West Arm. There are not many islands. A few small ones are at the upper end opposite and near the entrance of the West Arm. A large one is opposite the east side of the entrance to the Narrows. There are also a few that at high water are mostly submerged and at low water merely dry shoals, but which were probably originally small islands.

The principal tributary streams besides the main inlet are the following: At the extreme northern end the outlet of the Richardson Ponds enter the lake through an extensive swamp. The Richardson Ponds are designated as the East and West Richardson Ponds, of which there are two each. The eastern ponds are small and flow into the lower of the western ponds, which is about the same size as the eastern ponds. The principal pond of the group is one of the western pair and only a short distance from the lower one. It is about 1¾ miles long by three-fourths of a mile wide, irregularly elliptical in shape, with a large island about the middle and a small one near the outlet. In a direct line by the way of the outlet the foot of this pond is only a little over one-third of a mile from the lake, but following the stream it is considerably farther, as the stream is very winding. Also flowing into the north end of the lake is Beaver Brook, which pursues a meandering course in an easterly direction conveying the waters of Beaver Pond, only one-fifth of a mile distant from the lake in a direct line from the mouth of the brook and much less from the head of the West Arm. Beaver Pond is irregular in shape with a strongly projecting shore line and consequent deep coves. Beaver Pond is about 1¼ miles long with an extreme width of about three-fourths of a mile and has an area of about 0.93 square mile. There appear to be no other brooks of consequence on the western side of the lake. The largest is a dead-water outlet of a large swamp situated about 3 miles from the head of the lake.

On the east side Mill Brook flows into the lake nearly opposite the West Arm. On the same side of the lake, about $1\frac{9}{10}$ miles southward of the inlet, Mosquito Brook enters the lake, and about $2\frac{3}{10}$ miles from the mouth of Mosquito Brook is the mouth of Metallak Brook. Metallak Brook flows into a broad cove directly behind the previously mentioned island near the east side of the entrance to the Narrows. Metallak Brook is formed by three or more ramifications. About three-fourths of a mile from the lake it is joined by a branch that discharges the waters of Metallak Pond, about 2½ miles southeast of the lake. This pond is about three-fourths of a mile long and a scant one-fourth of a mile wide and is narrowly elliptical in shape.

Lower Richardson.—The other expansion, known as Lower Richardson or Wellekennebacook Lake, is not quite as long but somewhat wider than the upper lake and is also crescentic in shape, the convexity being to the westward, giving the two lakes combined a sort of a reversed S shape. The total length in a general northwest and southeast direction is about $5\frac{3}{10}$ miles. The greatest width of about $1\frac{1}{2}$ miles is in the upper portion, whence it narrows to one-third of a mile or less. The immediate shores are, for the most part, considerably higher than those of the upper lake. The shore line is fairly regular and there are few strongly projecting points. Horse Beef Point on the western side is near the foot of the Narrows, and about two-fifths of a mile from this point on the same side of the lake is another prominent cape known as Jackson Point. The southern end of the lake gradually tapers to the extremity of what is known as the South Arm. There is no landmark defining the beginning of the South Arm, unless it is a small abrupt projection from the eastern side, known as Hardscrabble Point, a little over 2 miles from the foot of the Narrows and something over 3 miles to the extreme head of the South Arm. At the inner portion of the South Arm is a chain of islands and connecting bars inclosing a shallow-water area known as the Pocket. At the end of this place the immediate shore is low and there is only 17 feet height of land between high-water line and the headwaters of Black Brook, a tributary of the Androscoggin River. There are but few other islands, and they are very small. The most noted of these is Spirit Island, not far southward of Hardscrabble Point. Its name indicates its legendary origin.

There are no important tributaries. The largest is Black Cat Brook, entering the western side of the lake some distance below Middle Dam Cove.

The dam that controls the flow of these lakes is known as Middle Dam, and is about 170 feet between abutments. It is a house dam, completely controlling the flow through the gates, with no provision for an open overflow or weir. The sill of the dam is 197.08 feet above that of Errol Dam at the head of the Androscoggin, just below Umbagog Lake. The dam, which is about 22 feet from sill to floor, will hold a head of about 21 feet.

The combined area of the two lakes at high-water line is 13.08 square miles, having a total capacity of 5,294,276,000 cubic feet. The general depth of Molechunkamunk Lake is somewhat less than that of Wellekennebacook. At the northern end and between the mouth of Mill Brook and the islands and bar obstructing the entrance to the West Arm the depth ranges from 17 to 32 feet, but within the West Arm a considerable portion carries a depth of 72 to 87 feet. The 87-foot point is the deepest water of the lake. In the main lake the deepest soundings made are at a point about midway of a line across the lake and about four-fifths of a mile above a parallel line drawn across from the inlet, where 82 feet are found. Between this point and a line from the mouth of Mill Brook the depth varies in the deepest portions from about 40 to 50 feet. About midway of a cross line from the inlet 80 feet of water occurs, shoaling both easterly and westerly but carrying a good depth to very near shore. The deep portion of the lake then carries depths ranging gradually from about 80 down to about 20 or 30 feet just before the Narrows are reached. The upper half of the Narrows carries 30 to 40 feet and the lower half 12 to 30 feet of water. In a line from Jackson Point to Lakewood Camps Wharf on the northern side of the outlet cove, a distance of 1 mile, the depth ran from 27 feet at the point to 48 feet about one-half the distance from the point, thence down to 12 feet near the wharf. In a line from Jackson Point directly across to the eastern shore the water deepened from 41 feet not far from the point to 78 feet about halfway across, thence shoaled to 23 feet about one-tenth of a mile from shore. In a line from the termination of the last line mentioned to the Lakewood Camps Wharf, again starting with a depth of 15 feet not far from shore, within two-tenths of a mile 73 feet occur, which deepen to 91 feet about 1 mile from Lakewood Wharf, toward which it gradually shoals. Again, in a line from Lakewood Wharf to a point about one-third of a mile northward of Hardscrabble Point the water gradually deepens without much variation to 98 feet about 1 1/5 miles from the wharf, thence for the remainder of the distance, about four-tenths of a mile, it shoals to 22 feet not far from shore. Another line of soundings from the same wharf approximately in a mid line down the South Arm finds 100 feet, the deepest of the lake, about 1 1/3 miles from the wharf. Thus far the deepening was gradual, but from this point on the bottom seemed to be more or less irregular, and there is a depth fluctuating between 48 and 81 feet for about 1 1/2 miles farther, where the water is generally not over about 30 feet. Within the Pocket the deepest water is only 8 and 9 feet.

THE OUTLET OF RICHARDSON LAKES.—The outlet of Richardson Lakes is Rapid River, which is about 6 miles long, connecting these lakes with Umbagog Lake, in this distance falling about 200 feet. Slightly over one-half of a mile below Middle Dam is an expansion of the river known as Pond-in-the-River. This pond has an area of 0.83 of a square mile and a capacity of about 86,981,000 cubic feet at high water. It is irregularly triangular in shape, the apex being at the southeast end and the inlet entering at the eastern and the outlet leaving at the western basal angle. The distance from the mouth of the inlet in a straight line along the eastern shore is nearly 1 3/8 miles and something over 1 3/16 miles to the quick water of the outlet.

The northern side of the pond curves irregularly southward, forming a broad or rounded point somewhere near midway between the inlet and outlet. In a straight line from this point to the apex of the triangle it is nearly 1 1/8 miles, carrying a depth of water from 10 feet near this point to 30 feet not far from the southern end of the pond. There is a fairly general depth of 19 to 29 feet. There are a few shoals at times becoming islands, in the pond.

A small brook enters the apex from the southward and another from the northward enters the cove immediately west of the mouth of the outlet.

The fall of Rapid River, previously mentioned, makes the stream a very quick one all the way to the level of Umbagog Lake. The present dam at Errol has flooded the lake to such an extent that it extends a broad dead-water arm up the Rapid River to the so-called falls, some miles from the old mouth of the river. The river is very rocky and contains bowlders of various sizes from pebbles to those of tons in weight, and there are, consequently, many pools and eddies in its course.

Locally, frequent mention is made of the falls of Rapid River. There is no decided pitch or abrupt waterfall in the course of the stream. The term falls merely distinguishes the rapid portion from the lower, or dead water, part of the river.

UMBAGOG LAKE.

This lake, lying partly in Maine and partly in New Hampshire, is the lowermost in the Rangeley chain of lakes. It has an elevation at high water of 1,246.3 feet above the sea and is the immediate source of the Androscoggin River. It seems never to have had any other than its aboriginal name.

The lake is irregular in shape, proportionally long and narrow, with many deep coves and resulting points. Nearly two-thirds of it is in New Hampshire. The general direction of the lake is north and south. From the extreme southern portion to the most northern end is about 7⅘ miles, and from the same southern point (Lakeside) to the entrance of Sunday Cove at the northeastern end is about 9 miles. Its irregularity of shape prevents exact determination of the greatest width, but approximately it is about 2 miles and the average from one-half to 1 mile. The distance from Errol Dam to Sunday Cove Landing, via boat route, including the crooked channel, is about 8⅘ miles.

At its northern end is a large area that may be designated as a bay, its right to this name being bestowed by a broad cape that projects from the eastern shore in a northeasterly direction into the lake and Moose Point, on the opposite northwest shore about one-half a mile distant. The distance across this cape at its northwestern end is approximately 4,000 feet. The northern corner is called Brandy Point and the southwestern corner Pine Point. Opposite and slightly northward is the entrance to the Androscoggin River. The distance to this river directly across from Pine Point is about three-fourths of a mile; from Brandy Point to the shore directly north is nearly 2 miles.

The area of Umbagog is 15.8 square miles, second in size to Mooselucmaguntic and a little larger than the combined Richardson Lakes. Its total capacity of 3,476,715,000 cubic feet is greater than Oquossoc but considerably less than the Richardsons. This is due to its shallowness, it being the shoalest of all the lakes.

The lake carries a general depth of 10 to 17 feet. The deepest places are two so-called deep holes, one situated off Sunday Cove the other not far distant from the mouth of Rapid River. In the first place, the Maine Water Storage Commission reports 46 feet, in the latter 43 feet. In 1905, during a stage of retained waters, the Bureau of Fisheries' party got about 50 feet in each place. The larger coves quite generally have water from 6 to 8 or 9 feet deep, sometimes close to shore, except in the smalier adjunct indentations.

The contours of the lake in general follow fairly close to the shores, except in the northern half, where considerable flat land occurs. This is especially true along the outlet and in the lower part of the Magalloway, where extensive meadows appear that are flooded at high water. A similar condition exists at the mouth of Cambridge River, to be described later. These places at certain stages of water form large lagoons, locally known as "logans," which harbor a great deal of aquatic life and afford rich feeding places for the various fishes to which the shallow warm water is not uncongenial.

The bottom of the lake is composed mostly of rather soft mud, and the coves, especially the shallow ones, produce a profuse growth of vegetation.

There are but few islands, most of which are in the lower or southern portion of the lake. Southwestward of Tylers Point is Metallak Island, shown on recent maps as Duttons Island, a summer cottage of a Mr. Harry Dutton being located there. His residence occupies about one-half of the island, which has a sea wall surrounding it. It is said that during high water in the spring the island is flooded, the water at times reaching nearly to the foundation of the house. South and west of this island are several small ones, and one large one, known as Big Island, situated off the mouth of Thurstons Cove. Big Island is irregularly quadrangular in shape, its long axis of about four-fifths of a mile lying east and west. Its greatest width, about three-fourths of a mile, is at the western end; it is constricted a little east of the middle to three-eighths of a mile; and is approximately one-half of a mile wide at the eastern end. The location is such as to make two comparatively narrow passageways from the southern to the northern portions of the lake—one by the western shore toward Thurstons Cove, thence about one-third of a mile across from the lower western angle of the island and carrying from 6 to 8 feet of water; the other about the same distance from Tidswells Point, with 10 to 12 feet of water.

Coves.—The principal coves are Sturtevants, Sunday, Rapid River, B Brook, and Tylers from north southward on the east shore, and Sargents, Thurstons, and Block Island from south northward on the west side. Sturtevants Cove is a broad cove a short distance northward of the entrance to Sunday Cove. Its northwestern shore is rather low and the southeastern comparatively high rising ground. Not far from the high shore the cove carried a depth from 17 to 7 feet toward the mouth of Sturtevant Brook.

Sunday Cove is situated at the northeast side of the previously-mentioned large bay. From the entrance to head it is 1 mile and has a greatest width of about one-third of a mile, but the entrance is only one-tenth of a mile across. It is near the head of this cove that the steamboat landing for the Rapid River carry to Middle Dam is located. Something less than a mile south of the entrance to Sunday Cove is the cove at the mouth of Rapid River. About 1½ miles southward of Pine Point is the entrance to B Brook Cove, which is an indentation nearly 1 mile long and about one-third of a mile wide. The southern side rises more abruptly than the northern side and is formed by the northern shore of a broad cape the southern projection of which is Tylers Point. Immediately south of Tylers Point is a broadly triangular, comparatively deep-water cove called Tylers Cove. It carries 14 feet of water well up into the cove, the shores of which are fairly steep, especially on the north side.

Sargents Cove is a shallow-water indentation at the west end of the east and west southern expansion of the lake. It is triangular in shape and has only 4 or 5 feet of water in the deepest part. From the point bounding the northern side of the cove the shore of the lake runs very regularly northwestward for about 2 miles to the entrance to Thurstons Cove, which is irregularly triangular in shape, nearly a mile long, with water shoaling from 6 feet at its entrance to 1 foot at the head. Block Island Cove is small, shallow, and of not much consequence. It is situated about 1 mile northwestward of Metallak Island.

Situated between a low marshy point at the southern side of the present entrance of the Androscoggin River and the comparatively steep southern shore at Molls Rock, is a small cove that is, in some portions, 10 feet deep. The head of the cove is only a few yards from a bend in the Androscoggin River. A boat or canoe portage here is known at Molls Carry.

On the north side of the river entrance is another long marshy neck of land only a few yards across, by which over a mile of distance is saved by using Richardson Carry in boating or canoeing from the upper end of the lake. This region about the entrance of the river south and westward of Moose Point consists of shallow water, lagoons, and marsh.

Tributaries.—The largest and most important affluents of Umbagog Lake are Rapid River, the outlet of the Rangeley Lakes above, and Cambridge River.

Rapid River.—From Pond-in-the-River this stream pursues a rocky and more or less turbulent course, as may be inferred from its name, for a distance of about 5 miles, having a fall in that distance of about 200 feet. The rapid portion of this stream, as has been previously stated, is commonly referred to as the falls, but there are no distinct pitches that could be properly designated as waterfalls. Huge bowlders and ledges *in situ*, however, cause very rough water in many places when the stream is high. The low ground at the lower end of the river and the overflow from high stages of water in Umbagog Lake make a wide area of still water for about 1 mile in a direct line to the foot of the falls. At low stages of the lake and river the channel from the falls is more or less winding and the current is far from rapid. The bottom of the stream in the dead-water portion is mainly muddy, and there is much aquatic vegetation here, as well as in the overflowed areas or lagoons left by receding waters.

Cambridge River.—This stream enters Umbagog Lake at the eastern end of the southern east and west expansion, the debouchure being at Upton Mills, where for many years there has been a dam completely obstructing the stream. Below the dam there is a low ledgy drop into the still water of the river channel in the lake. Formerly the river extended through meadowland for a direct distance of over 1 mile. At low water it is a winding channel with dikelike banks beyond which is shallow water or flats. At high water the dike is nearly or quite covered, especially at the lake end, and at lower stages of water there are occasionally passages through into the lagoons.

The Cambridge River is formed by two branches, which unite about 3 miles above Upton Mills to form the main river. The branches are known, respectively, as Swift and Dead Cambridge. The Swift Cambridge has its principal source in Grafton, Me., near Bald Mountain, where two or more small brooks unite. One brook rising in Grafton Notch has its source very near the Bear River, a tributary of the Androscoggin. Another, the principal brook source, rises in York Pond among the hills north of the mountain. This pond is about 4 acres in extent and very shallow, the greatest depth being about 7 feet, in one place only. The inlet at the east end of the northern side of the pond is a short thoroughfare connecting it with a small pond of about 2 acres in extent and of about the same depth as York Pond. The shores of both ponds are bordered more or less with boggy ground with the ordinary bog shrubs. The outlet leaves the pond at its north side and is a small, swift, abruptly graded mountain brook almost all the way to its junction with the other branch.

At Grafton, from the junction of the brooks, the Swift Cambridge rapidly increases in size, but for some distance it is a deep, comparatively slowly flowing stream. The character of the stream between Grafton and the pond above the dam near the Andover Road bridge was not ascertained. Above this dam the pond is several acres in extent but long and narrow. Below the dam the river is quick water, rocky, and full of bowlders, with now and then some deep pools and eddies down to its junction with the Dead Cambridge.

The Dead Cambridge rises in C Pond in C Surplus and flows westward for about 4 miles in a direct line to its junction with the Swift Cambridge. The Maine Water Storage Commission report gives the area of C Pond as 0.52 of a square mile. The Dead Cambridge issues as a small alder-covered brook, which condition obtains for one-half of a mile or more to a meadow and overflowed area produced by an old gate dam known as the Sluice. The Sluice is estimated to be 8 miles from Upton Mills, following the river. From the alder-tangle portion of the brook to the upper end of the pond produced by the backed-up water above the dam it is a grassy meadow interspersed with clumps of bushes and trees. Through this meadow the brook averages, perhaps, 16 or 18 feet in width, much narrower in some places and considerably wider in others, especially in the pools. The stream is everywhere very sinuous, the pools are very deep, and the bottom mostly of sand. In many instances, especially on the deep side, the pools are overhung with alders, and each pool has its greatest depth at one side or the other, usually on the short bend. The backwater above the Sluice extends as a moderately wide but shallow pond for perhaps one-half of a mile above the dam.

The Sluice is situated between two high and steep ridges or moraines, commonly called horsebacks, which, diverging, extend some distance downstream, leaving a narrow margin of meadow on the right-side part of the distance but wooded steep shores on the other. The stream emerges from this region, the lower end of which bears the local name of the Onion, into an extensive meadow, estimated to be 2 miles in length and fully a mile in width. Through this meadow, which is covered with a prolific growth of meadow grass and "Joe-Pye weed" (*Eupatorium purpureum*), the brook pursues a very winding course to its junction with the Swift Cambridge. Throughout its course there is no quick water, except a little just below the Sluice, and the bottom is sandy or muddy, mostly sandy, all the way. From the Sluice to the meadow the stream is generally deep, with frequent large, deep pools, but through the meadow it is generally shoal with an extensive growth of pond weed (*Potamogeton*).

From the junction of the Swift and Dead Cambridge branches, known as the Forks, the Cambridge River is a slowly flowing stream perhaps 50 or 60 feet in general width but varying considerably. The country is here low and wooded, with many lagoons produced by spring freshets and the changing course of the stream. The banks and bottom are mostly sandy and the stream varies in depth, having here and there wide deep pools and shallow reaches covered with a profuse growth of water plants, consisting of two kinds of yellow pond lilies, pond weed, etc. The water is dark red, almost black in deep places. The foregoing conditions were those observed in July, August, and September, but in the spring the river discharges a large volume of water and the current of even the Dead Cambridge is far from mortal slowness.

Upton Mills dam forms a pond of considerable extent, the bottom of which is mainly muddy from deposits by the river and decaying vegetation. Power for a sawmill is furnished by this pond.

Next in importance as a tributary of Umbagog is B Pond, situated in Upton, formerly Township B, 3 miles in a direct line from Umbagog Lake but only about a mile in a direct line from Rapid River about a mile below Pond-in-the-River. The Maine Water Storage Commission report gives the area of B Pond as 0.90 of a square mile. The pond is irregularly cycloid in shape, and there is a comparatively large island near the southwestern shore. B Brook discharges its waters into Umbagog Lake at B Brook Cove. Its course is very irregular, almost entirely through woodland and bogs.

Sturtevants Brook is a small brook flowing into Sturtevants Cove.

Sunday Brook flows from a small pond about 1 mile in a direct line from Sunday Cove, into which it empties.

Several other rivulets, some of which are entirely dry during the summer, others perennial spring-fed brooks but which have no names, flow into the lake at various places. The importance of these little brooks is mainly that in the spring and early summer young trout and other fishes occur in them. Three of these brooks were to some extent studied and were given names for convenience in note making, and the names have been used in this report and on the maps. Wildcat Brook is a hillside brook of very small size that flows into the lake at the southern end a short distance from Lakeside. It was full of water up to July 10 and entirely dry on July 14. Another small brook, which contained some water throughout the summer, flows from some springs in the open pasture back of the Lakeside House and empties into the lake at the foot of the hill near Lakeside post office. It was named P. O. Brook. Thurstons Brook, flowing into Thurstons Cove, has its source in Bullhead Pond. This pond derived its name, not from the presence of the catfish of that name, but because it was by the obstinate persistence of one of the party in following a certain direction that the pond was found. It is a small, shallow, muddy, plant-grown pond with scarcely any rocks visible about the shore and bushes growing to the water's edge. It is situated about 1½ or 2 miles from Thurstons Cove at a considerable elevation, so the brook is a purling rivulet for most of its course.

The Magalloway River system may be considered as practically tributary to Umbagog Lake, inasmuch as it discharges into the Androscoggin River above Errol Dam, not far below the lake.

Magalloway River is a much ramified and very sinuous stream, having its extreme headwaters in the Boundary Mountains. Mention has already been made regarding the contiguity of these sources and those of some of the branches of the upper waters of the Connecticut River. The Magalloway drainage area is given by the Maine Water Storage Commission report as 460 square miles. The greater part of the river is located in Maine. It leaves the State for a short distance about 6 miles in a direct line from the mouth of the river. It permanently leaves the State about 4½ miles in a direct line from the mouth of the river, or a little over 4 miles in a direct line below Wilson's mills. Its immediate source is in Parmacheenee Lake, the area of which is shown by the Maine Water Storage Commission report to be 4.35 square miles. The most important Maine tributaries are the Little Magalloway, Black Cat Brook, North Branch Brook, Metallak Pond and Brook, Lincoln Pond and Brook, and Sturtevant Pond and Brook—all below Parmacheenee Lake and noted as trout waters. The largest and most noted tributary is the Diamond Stream, wholly in New Hampshire, which joins the Magalloway at its first point of departure from Maine. The upper course of the river below Parmacheenee Lake for a comparatively short distance is quick water, thence to Aziscohos Falls, some 13 miles in a direct line below Parmacheenee Lake, it is overflow, produced by a dam at the falls. The area of the overflow prior to the completion of the new Aziscohos Dam is stated to have been 6.5 square miles. This new concrete dam has increased the flooded area to 10.5 square miles, making a storage reservoir about 14 miles long with a capacity of 8,000,000,000 cubic feet. Most of the course of the river below Aziscohos Falls is smooth water and usually navigable by small steamboats nearly to the mouth of Sturtevant Brook, about 3 miles in a direct line, but much more by river, from the mouth.

Errol Dam, located 5 miles below the outlet, controls the storage of Umbagog Lake and is about 3½ miles below the mouth of the Magalloway River, thus making the latter stream one of the feeders of Umbagog Lake.

The Androscoggin River from the lake to the mouth of the Magalloway is a winding channel between two naturally formed dikelike embankments, with here and there openings into the lagoons beyond. Beyond the Magalloway's mouth the banks are low but wooded, without much swampy ground except at the mouths of brooks and narrow strips of lagoonlike areas by the river and margin, probably formed by slight changes in its course or conditions. The channel has a depth ranging from 12 to 37 feet. The bottom is mainly muddy. The immediate margin bears a profuse growth of water plants, and patches of yellow water lilies are everywhere of frequent occurrence.

The dam is a wooden structure completely housed over and 175 feet long between abutments. The entire flow passes through various gates of different sizes. There is no provision for overflow besides the gates.

Below the dam there is a decided decline, occasionally an almost torrential rapid, when the water is on. Immediately below the dam, especially on the right side of the river, the shore is an almost precipitous rocky cliff, at the foot of which is a deep pool formed by an eddy. The quick water ends in a broad expanse of smooth water at Errol below the bridge. Here, from the right, enters a considerable tributary known as Clear Stream. Thence for about 3 miles to Molnichwock Falls the current is strong but smooth.

The next principal tributary of the Androscoggin below the lake, and the only other one with which this report is concerned, enters the Androscoggin from the left just above Molnichwock Falls. This is Molnichwock Brook, which at the river end is a narrow dead-water area, perhaps one-half mile long, bordered by an extensive shrub-grown bog or marsh. In high stages of water the stream may be navigated by canoe for 4 or 5 miles before it becomes obstructed by overgrowing and ingrowing alders and other bushes. The stream rises in Molnichwock Pond in Maine, about 9 miles in a direct line from its mouth.

Molnichwock Pond is irregularly cycloid in shape and of an estimated area of about 20 acres. It is situated among the wooded hills of Upton. The immediate shores in most places consist of a narrow border of bog with the shrubs characteristic of such places. Around the shore margin is a zone of yellow pond lilies and other aquatic plants. The bottom is mostly of soft mud. The depth at the outer edge of the lily growth was about 6 feet. A line of soundings through the middle, west to east, at approximately equal intervals, gave 7, 7½, 8, 9, 9, 9, and 9 feet, shoaling gradually on the west and northwest sides; 7 feet of water was found nearer shore on the east and southeast sides. The deepest water was 8 and 10 feet on the east and southeast sides about 50 feet from shore and about 40 yards from shore on the west side. There is a large shoal at the outlet at the east side of the pond.

The outlet of the pond is a very small rocky brook, which condition obtains for an unknown distance. In its course, perhaps 6 or 7 miles from the mouth of the stream, are two meadows, the smaller not far above the larger and the two separated by woodland and alder growth. The lower meadow is grass grown, with here and there clumps of alders and other bushes and trees, especially on the margin of the brook. Through this meadow, which is perhaps 1 mile long in a direct line, the brook, with many shoal reaches and deep pools, winds its way over a sandy bottom. Most of the shoals bear a growth of water plants, mostly of pond weed. Below the meadow for a long distance, probably all of the way to the meadow near the mouth, the brook flows through a narrow bottom land, on each side of which are steep hills. This bottom is a close growth of alders and other small trees entangled with clematis vines and bedstraw. In this locality the brook varies also from shoals to broad deep pools, usually with sandy, but sometimes with clay, bottom.

If it were not for the alders bent down and growing horizontally across the brook with consequent jams of débris, there is usually water enough to afford canoe passage to the mouth of the brook. An occasional fallen tree also obstructs, but such obstruction is more easily surmountable than long areas of low-lying alders. As previously stated, the lower end of the brook flows through a bog such as is commonly designated as a heath, especially at its upper end, but decidedly meadowlike farther down. The brook bottom is entirely sandy until the mouth is reached and with shoals and deep pools, some of which are 30 feet across, deepest on the long curve and often a sand spit on the short one.

FISH FAUNA OF THE RANGELEY LAKES.

The recorded fish fauna of the Rangeley Basin is a limited one, at present consisting of only 19 species, of which 13 are native—if the eel can be called native—the other 6 having been introduced, and there is no certainty that one of these has become established.

In their geographical faunal relations, in a few instances, these waters are peculiar, and this fact was noted many years ago. In 1862, C. H. Jackson [a] said:

> These Androscoggin Lakes generally afford grander scenery than any others in the State. Their waters afford several kinds of fishes not found elsewhere, and wild animals are common in the forests adjacent, so that there are fine places of resort among them for the student of natural history. The *Salmo oquassa* Girard, or blueback trout, an uncommon variety of dace, and a red-sided sucker are peculiar to these waters. The togue and pickerel are not found here.

At a meeting of the Boston Society of Natural History,[b] October 5, 1864, F. W. Putnam remarked that until the present season he had thought that the Great Lakes fauna had extended to the larger lakes of Maine, but from his exploration of the Richardson chain he was now convinced that such was not the case, as there were but 3 or 4 of the 14 species of the Richardson Lakes which were of the same species as those of Lakes Champlain and Superior. The absence of the perch, bream, shiner, pout, pickerel, and the cyprinodonts in the Richardson Lakes was a marked characteristic of that fauna, distinguishing it from that of the Great Lakes. And in speaking of the Sebago Lake fauna he went on to say that there was also a *Lota* and a species of *Salmo* not found in the Richardson Lakes.

In continuation of the discussion, Dr. Pickering stated that he had passed the summer on the Androscoggin River, 25 miles from Lake Umbagog, the lowest of the Richardson Lakes, and that he had found the chub abundant and the pickerel not rare. Perch had been taken there for the first time during that season. Mr. Putnam remarked in response that the fishes of the Androscoggin River were different from those of the lakes at its headwaters, and that but few species passed from the river to the lakes. A species of *Lota* had been taken in the Androscoggin but never in the lakes, so far as he was aware. The eel had been occasionally found in the lakes at Upper Dam but never in the lakes above that dam.

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[a] Second Annual Report upon the Natural History and Geology of the State of Maine, 1862, part II, p. 327, 328.

[b] Proceedings, Boston Society of Natural History, X (1864–1866), 1866, p. 64.

The indigenous species of this region thus far recorded are the following: Long-nose sucker (*Catostomus catostomus*), common sucker (*Catostomus commersonii*), chub (*Semotilus bullaris*), blackspot chub (*Semotilus atromaculatus*), chub minnow (*Couesius plumbeus*), brook shiner (*Rhinichthys atronasus*), bronze minnow (*Phoxinus neogæus*), redfin (*Notropis cornutus*), shiner (*Notemigonus crysoleucas*), eel (*Anguilla rostrata*), trout (*Salvelinus fontinalis*), blueback (*Salvelinus oquassa*), and Miller's thumb (*Cottus gracilis*).

Of the six introduced species, all but one (*Salvelinus aureolus*)[a] have become more or less established and there is some doubt about the correctness of the record of the planting of that one in Rangeley Lakes. The brown trout (*Salmo fario*) has been planted in Loon Lake and Cow Pond, both of whose waters are in the Rangeley region but belong to the Kennebec system. The introduced species that have become established in one or more of the lakes are: Hornpout (*Ameiurus nebulosus*), whitefish (*Coregonus clupeaformis*), salmon (*Salmo sebago*), smelt (*Osmerus mordax*), and pickerel (*Esox reticulatus*).

The following table of geographical distribution of 39 indigenous and introduced fresh-water species includes only those that have been recorded as caught in those waters. The items in the column for Rangeley Lakes are not repeated in the Androscoggin River Basin column except when records are common to the two localities.

TABLE 1.—RECORDED GEOGRAPHICAL DISTRIBUTION OF FRESH-WATER FISHES, INCLUDING INTRODUCED SPECIES BUT NOT ANADROMOUS INDIGENOUS FORMS, IN WESTERN MAINE AND NORTHEASTERN NEW HAMPSHIRE WATERS.

Name of species.	Rangeley Lakes.	Androscoggin River Basin.	Presumpscot River Basin.	Kennebec River Basin.	Upper Connecticut River Basin.
Hornpout (Ameiurus nebulosus)	[b] ×	×	×	×	
Long-nose sucker (Catostomus catostomus)	×				×
Common sucker (Catostomus commersonii)	×	×	×	×	×
Chub sucker (Erimyzon oblongus)			×		
Red-bellied minnow (Chrosomus erythrogaster)		×		×	×
Chub (Semotilus bullaris)	×	×	×	×	×
Blackspot chub (Semotilus atromaculatus)	×	×		×	×
Chub minnow (Couesius plumbeus)	×	×	×	×	×
Brook shiner (Rhinichthys atronasus)	×	×	×	×	×
Long-nosed brook shinner (Rhinichthys cataractæ)					×
Bronze minnow (Phoxinus neogæus)	×			×	×
Bridled minnow (Notropis bifrenatus)			×		
Redfin (Notropis cornutus)	×	×	×	×	×
Shiner (Notemigonus crysoleucas)	×	×	×	×	
Eel (Anguilla rostrata)	×	×	×	×	×
Whitefish (Coregonus clupeaformis)	[b] ×				
Whitefish (native) (Coregonus labridoricus)			×	×	
Round whitefish (Coregonus quardilateralis)				×	×
Chinook salmon (Oncorhynchus tschawytscha)				[b] ×	
Landlocked salmon (Salmo sebago)	[b] ×	[b] ×	×	[b] ×	[b] ×
Brown trout (Salmo fario)		[b] ×		[b] ×	[b] ×
Lake trout (Salvelinus namaycush)		×		×	×
Blueback (Salvelinus oquassa)	×				
Trout (Salvelinus fontinalis)	×	×	×	×	×
Smelt (Osmerus mordax)	[b] ×	×	×	×	
Cobosseecontee smelt (Osmerus abbottii)				×	
Wilton Pond smelt (Osmerus spectrum)				×	
Pickerel (Esox reticulatus)	[b] ×	×	×	×	×
Shore fish (Fundulus diaphanus)		×		×	

[a] Report on the propagation and distribution of food fishes, by John W. Titcomb. Report Commissioner of Fisheries for the year ending June 30, 1904 (1905), p. 64.

[b] Introduced.

TABLE 1.—RECORDED GEOGRAPHICAL DISTRIBUTION OF FRESH-WATER FISHES, ETC.—Continued.

Names of species.	Rangeley Lakes.	Androscoggin River Basin.	Presumpscot River Basin.	Kennebec River Basin.	Upper Connecticut River Basin.
Brook stickleback (Eucalia inconstans)				×	
Fresh-water stickleback (Gasterosteus atkinsii)		×		×	
Ninespine stickleback (Pungitius pungitius)		×	×	×	
Long-eared sunfish (Lepomis auritus)		×		×	
Pumpkinseed (Lepomis gibbosus)		×	×	×	
Black bass (Micropterus dolomieu)		[a] ×	[a] ×	[a] ×	
Perch (Perca flavescens)		×	×	×	
White perch (Morone americana)		×	[a] ×	×	
Miller's thumb (Cottus gracillis)	×	×	×	×	×
Burbot (Lota maculosa)		×	×	×	×

[a] Introduced.

The following table gives the distribution of the species found in the Rangeley Lakes as shown by the writer's records and observations only. Doubtless waters for which there are no records contain most of the species recorded for any body of water of the system.

TABLE 2.—DISTRIBUTION OF SPECIES FOUND IN RANGELEY LAKE AND TRIBUTARIES BY THE AUTHOR.

Name of fish.	Oquossoc.	Mooselucmaguntic.	Richardson.	Umbagog.
Hornpout (Ameiurus nebulosus)	×			×
Long-nose sucker (Catostomus catostomus)		×		×
Common sucker (Catostomus commersonii)	×			×
Chub (Semotilus bullaris)	×		×	×
Blackspot chub (Semotilus atromaculatus)	×			×
Chub minnow (Couesius plumbeus)	×		×	×
Brook shiner (Rhinichthys atronasus)				×
Bronze minnow (Phoxinus neogæus)				×
Redfin (Notropis cornutus)	×			×
Shiner (Notemigonus crysoleucas)				×
Eel (Anguilla rostrata)			×	
Whitefish (Coregonus clupeaformis)				×
Salmon (Salmo sebago)	×	×	×	×
Blueback (Salvelinus oquassa)	×	×	×	
Trout (Salvelinus fontinalis)	×	×	×	×
Smelt (Osmerus mordax)	×	×		×
Pickerel (Esox reticulatus)				×
Miller's thumb (Cottus gracilis)				

TABLE 3.—DISTRIBUTION OF SPECIES IN UMBAGOG LAKE, INCLUDING TRIBUTARIES AND OUTLET, 1905.

Name of fish.	Umbagog Lake.	Dead Cambridge River.	Swift Cambridge River.	York Pond.	Molnichwock Pond.	Molnichwock Brook.	Androscoggin at mouth of Molnichwock Brook.
Hornpout (Ameiurus nebulosus)	×						×
Long-nose sucker (Catostomus catostomus)	×						
Common sucker (Catostomus commersonii)	×	×				×	
Chub (Semotilus bullaris)	×	×	×				
Blackspot chub (Semotilus atromaculatus)		×	×	×	×		
Chub minnow (Couesius plumbeus)		×	×		×		
Brook shiner (Rhinichthys atronasus)		×					
Bronze minnow (Phoxinus neogæus)		×					
Redfin (Notropis cornutus)		×					×
Shiner (Notemigonus crysoleucas)	×						
Whitefish (Coregonus clupeaformis)	×						×
Salmon (Salmo sebago)	×						×
Trout (Salvelinus fontinalis)	×	×	×	×	×	×	×
Smelt (Osmerus mordax)	×						
Pickerel (Esox reticulatus)	×						×

HORNPOUT (*Ameiurus nebulosus*).

The hornpout is a member of the catfish family (Siluridæ), the membership of which is large and the natural distribution of which is very wide. The general geographical range of the hornpout, according to authorities, is the Great Lakes, the Ohio Valley, and eastward to Maine, southwestward to Texas, and southeastward to Florida; and its distribution has been extended even to the Pacific coast. This species is common in coastwise streams and lakes of Maine, and in certain river basins it is found in some of their most northern sources. It is not native to the Rangeley Lakes, although it occurs naturally in more southern waters of the Androscoggin Basin. Impassable natural barriers prevented its access to those lakes. The writer has been unable to learn the definite history of its introduction there. It was stated by a resident of Rangeley that a number of years ago some one brought a few to the region and planted them in a private pond, from which they escaped into the lake. Another introduction is said to have been purposely made in Umbagog Lake a number of years ago.

The hornpout thrives best in ponds and lakes with muddy bottom and profuse vegetation. It is an omniverous and indiscriminate feeder, but to a great extent subsists upon vegetable and animal life that it finds upon the bottom. It is also a scavenger when opportunities present. It is mainly a nocturnal feeder, but will eat by day or night. Moonlight nights are the most favorable for hornpout hook-and-line fishing. It is reputed to eat the spawn and young of other fishes. In Forest and Stream, January 30, 1904, E. A. Samuels wrote that he once caught a hornpout the stomach of which contained a small yellow perch, two or three snails, and a young trout of about 3 inches in length.

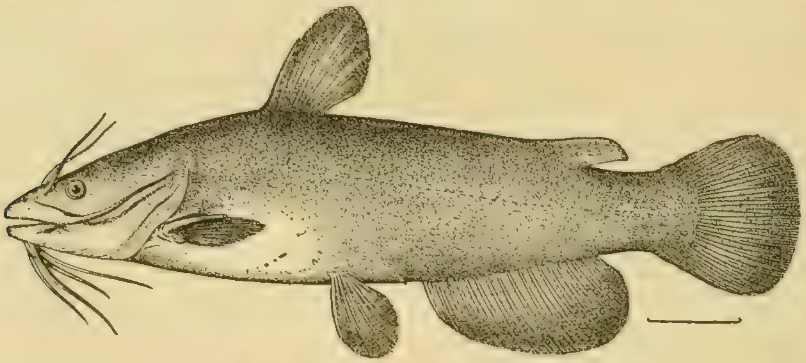

FIG. 1.—Hornpout (*Ameiurus nebulosus*).

It is said that the hornpouts hibernate. If the hibernation begins early enough, it removes one serious objection to its presence in Rangeley waters by minimizing the danger of its devouring trout and salmon spawn. However, it is doubtful if the hornpout reaches the spawning grounds of those species to an alarming extent even if it does not hibernate early, as they spawn in quick water, as a rule, and the hornpout affects quiet water. In this connection it may be mentioned that on October 21, 1904, the writer caught a large number of small hornpouts in a wire minnow trap set off the landing at the Mountain View House, Rangeley Lake. A peculiarity of these little hornpouts was their color, which was a beautiful purplish, iridescent bronze.

The breeding time of the hornpout in this region was not learned, but elsewhere it is usually in the spring. It deposits its eggs in a hole under rocks, old sunken logs, submerged stumps, etc. When hatched, one of the parent fish remains with the brood of young until they are at least an inch in length.

The hornpout is notoriously tenacious of life when removed from the water. Many stories in illustration of the fact have been related, but one that came under the personal observation of the writer is worthy of mention. On August 2, 1905, many hornpouts were caught in the seine at B Point. They were taken to the laboratory about 12.30 p. m. and thrown upon a piece of paper on the floor. The next morning at 9 o'clock (about 20½ hours after capture) four showed indications of life and they revived when placed in water.

This fish was found almost everywhere in Umbagog Lake throughout the season, especially in shallow coves at the mouths of brooks, where they were usually rather small. The largest observed were taken at the mouth of Sturtevant Brook and in the deep hole off Sunday Cove. They averaged about 1 pound each in weight. Hornpouts were also found in the Androscoggin River below Errol Dam and at the mouth of Molnichwock Brook. Most of those caught in Umbagog ranged from 3 to 8 inches in length.

The hornpout is an excellent food fish.

LONGNOSE SUCKER (*Catostomus catostomus*).

This sucker is sometimes called red sucker and red-sided sucker, owing to the red or reddish stripe that is frequently present along the side in the breeding season. It is also known as small-scale sucker. It is found from New Brunswick and New England westward to the Great Lakes and northward to Alaska, and in an isolated instance has been collected in the mountain waters of West Virginia. The earliest reference to its possible occurrence in the Rangeley Lakes was in the second annual report upon the Natural History and Geology of the State of Maine, 1862, part II, page 327, where the red-sided sucker is mentioned as peculiar to the Androscoggin Lakes. This reference was for a long time a doubtful one owing to the fact that the common sucker often has red sides. It was not positively recorded from Maine waters until a few years ago, when it was found in Craigs Brook. Subsequently, however, it was found to be quite commonly distributed, especially in the northern part of the State.

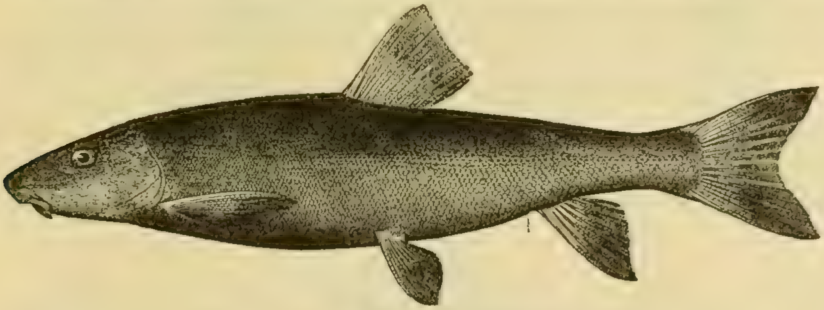

FIG. 2.—Longnose sucker (*Catostomus catostomus*).

Many years ago Prof. F. W. Putnam made a small collection of fishes in the Rangeley Lakes, which had remained unidentified in the museums of the Essex Institute and

Boston Society of Natural History until they were examined by the writer a few years ago. In the collection was found one specimen from Cupsuptic Lake. In 1905 the Bureau of Fisheries' party collected a number of specimens in Umbagog Lake.

There appear to be two distinct sizes of adult longnose suckers which have been generally regarded as this one species, the smaller size reaching only about 8 or 9 inches and the larger 18 inches or more in length. In some waters the smaller size only occurs—the Connecticut lakes, for example, where breeding fish 3¾ to 5⅔ inches long were found—and in others only the larger form is found, as in the Rangeley Lakes. But there are other waters where both distinct sizes occur, as in the Eagle Lakes of Fish River in Aroostook County, where the small form ranged from 5⅙ to 7⅔ inches in length. The two forms having somewhat different breeding seasons even in the same waters suggest the possibility of their being distinct species. In fact, in 1886, Mather[a] described the smaller one as distinct under the name of *Catostomus nanomyzon*.

This species is regarded as a comparatively deep-water fish, seldom entering shallow water except to breed or feed upon the eggs of other fishes.

Its breeding season in Rangeley waters has not been ascertained, but in some other waters of Maine it spawns in June. Its food, like that of the other suckers, consists mostly of minute animal and some vegetable life obtained from the bottom, and it is known to feed extensively upon the eggs of other fishes as well as its own.

On July 27, 1905, one was taken in a gill net off B Point, on July 28 another was caught, on August 3 several were taken, and on August 17 about 50 were taken by the same means and in the same place. On August 17 one was caught in a gill net in the deep hole off Sunday Cove. (See Table I, p. 590.)

The longnose sucker may be readily distinguished from the common sucker by its longer snout and more tapering head and finer and more numerous scales.

It sometimes takes a baited hook very readily and is a fairly good fish to eat.

COMMON SUCKER (*Catostomus commersonii*).

This is one of the widest distributed and well-known suckers, abundant in almost every stream, pond, and lake from Quebec and the Great Lakes to Montana and Colorado and southward to Missouri and Georgia. It reaches a weight of 4 or 5 pounds in some waters, and in others its largest adult size is only a few ounces. The largest taken by the Bureau of Fisheries' party in Umbagog Lake had a total length of 16 inches.

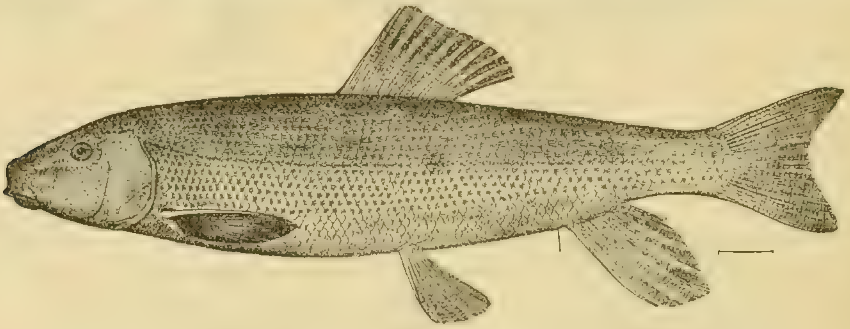

FIG. 3.—Common sucker (*Catostomus commersonii*).

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[a] Mather, Fred. Memoranda relating to Adirondack fishes, with descriptions of new species, from researches made in 1882, Twelfth Report, Adirondack Survey, appendix, zoology, 1886, p. 36.

This sucker feeds upon small animal and vegetable objects that it sucks up from the bottom, although occasionally it takes a baited hook, even rushing at it with the vigor of a trout, and it has been seen taking insects at the surface and has been caught on an artificial fly. It is a spawn eater, too, and is almost always present in large numbers upon the spawning beds of trout and salmon.

This fish is very prolific. It ascends streams, even rivulets when possible, to spawn. Its breeding season depends upon the latitude to some extent, but in Maine it spawns usually in May and June. The exact breeding time of this fish in Umbagog Lake was not ascertained.

Suckers, young or adult, were found almost everywhere throughout the season. The following localities were noted: Umbagog Lake, at various places; Wildcat Brook; Dead Cambridge; and Molnichwock Brook. It ranges in size from 1½ to 16 inches.

A few specimens, from about $5\frac{4}{5}$ to $6\frac{2}{5}$ inches long, taken in a minnow trap at Rangeley, October 17, 1900, were of a beautiful bronze coloration with a series of indistinct large blue-black spots along their sides. (See Table II, p. 591.)

CHUB (*Semotilus bullaris*).

Other names by which this widely distributed fish is known are fallfish, windfish, dace, silver dace, and chevin. It occurs commonly in eastern Canada and the United States east of the Alleghenies as far south as Virginia. Its size varies greatly in different waters and becomes larger in the North than in the South. In small streams and ponds it is correspondingly smaller, and in small brooks it reaches maturity when only a few inches long.

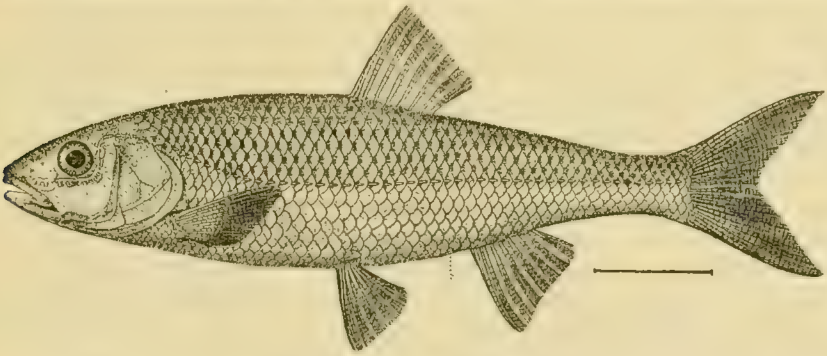

FIG. 4.—Chub (*Semotilus bullaris*).

The variation in appearance of the chub at all seasons is almost as great as the variation in size, and in breeding season the sexes differ much in color and somewhat in other respects. Small adult fish resemble young of the larger fish, being silvery and having a dark stripe along the sides. Larger fish are silvery, with the stripe showing but faintly or not at all, and still larger ones show no stripe and have dusky posterior exposed margins to the scales. The largest individuals have sexual and age variations, but in general it may be said that in these the colors are more evident and pronounced, the head being black, purple and blue, and yellow, with golden and bronze reflections; back, olive green; sides, purplish or bronze; belly, yellowish silvery, or white; posterior margin on lateral scales, black. The metallic luster and iridescence is beyond graphic description, and the artist's brush can but inadequately represent the varying hues and reflections.

The chub is almost omnivorous, eating everything that a trout will eat and much that the trout will not. Although toothless, it is a rather voracious fish eater. On August 12, 1905, in a "logan" at the entrance of the Androscoggin River, some fish that were at first supposed to be pickerel were observed pursuing some smaller fish, perhaps young chubs or other minnows. The smaller fish when pursued went skipping over the surface like skipjacks. Several of the larger fish were caught and found to be chubs of about one-half to 1 pound or more in weight, and were found to be feeding upon young pickerel 2 to 2½ or 3 inches long. Thus, while the chub affords food to other fishes, it takes a turn about.

As a game or food fish the chub is not highly esteemed. When hooked, it fights well for some time, but yields somewhat more quickly than the trout. It will take bait, troll, or fly. It will bite more readily than the trout, but is, however, sometimes wary and capricious. Sunshiny days are unfavorable for catching chubs. Small ones usually take the hook more readily than large ones.

That the chub is not esteemed as food is due rather to lack of flavor than to any disagreeable taste and also because other more delectable fish usually occur where the chub is caught.

The breeding habits of the chub are very interesting. Along the quiet reaches of streams or in shallow waters of ponds or lakes peculiar heaps of fine gravel or pebbles have been noticed, probably, by everyone traversing such places. These are the nests of chubs. In the Proceedings of the Boston Society of Natural History, vol. 1, 1844, p. 196, it is stated that at the meeting of September 4 "Dr. Wyman mentioned that on a late visit to the Magalloway River he had noticed in the river bed mounds of pebbles 2 or 3 feet in diameter, which he was told were heaped up by a fish called chub at its breeding season and that its eggs were deposited among the stones. He referred to the statement of a similar fact with regard to the lamprey eel, in Dr. Storer's report, and remarked that he was not aware of any other instance of the kind." Again, at the meeting of September 18, "Some conversation arose on the subject of the mounds in the Magalloway River, mentioned at the last meeting, supposed to have been built by the fishes for the purpose of depositing their eggs within the pile. Dr. Bigelow stated, on the authority of an experienced angler, that the stones are removed by the fish for the purpose of depositing the spawn in the cavity thereby left in the sand."

In the "Fishes of the Connecticut Lakes"[a] a detailed account is given of observations made by Supt. Charles G. Atkins, United States Bureau of Fisheries station, Craigs Brook, Me., May, 1878, from which the following is extracted:

> On May 8 a small chub was seen standing over a hollow at the lower end of a heap of gravel 3 feet long and 1 foot wide, and he repeatedly drove off other chubs, but by and by there came another larger male and drove away the little one and henceforth took charge of the nest. He was very vigilant, dashing immediately and furiously at every approaching fish just as landlocked salmon do. After a while, several times he was seen to take a pebble in his mouth and carry it to the heap and drop it. By and by a female came swiftly along and was seen struggling in an erect position over the lower end of the heap, with the male close to her, then she disappeared and the male remained alone over the nest. On May 9 the same large male was seen on the nest, but near him another smaller one, apparently a male, which the larger one did not this time drive away. The small one was later seen driving off others, and when the large one was absent would pick up stones and place them on the heap. But of all those that appeared to be females none lifted a stone. The large male was also at times seen to

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[a] Bureau of Fisheries, document No. 633.

convey pebbles to the heap. He was seen to make 15 or 20 trips to a gravel place on the opposite side of the brook and later, with pebbles from it, return to the nest, a distance of 6 or 8 feet. Sometimes he would have one stone and sometimes several small ones and rarely a mouthful of very fine gravel, and once a stick 3 or 4 inches long was brought and laid on the heap. There was then observed several times a sudden gathering of a number of supposed females from the immediate neighborhood, comprising all of the chubs within 5 or 6 feet or more, and a simultaneous rush for the nest, where only a confused mass of struggling fish could be distinguished, some of which turned over so that the gleam of the belly could be seen. The old male was always there.

The following communication, entitled "Stone luggers," appeared in Forest and Stream, June 23, 1881, page 410:

> During a recent visit to the Thousand Islands of the St. Lawrence I observed what I had never seen before, and something unfamiliar to most anglers. On the south shore of beautiful Round Island two mounds were discovered by a friend of mine situated, say, 10 feet from the water line and in about 3 feet depth of water. They were built of pebbles in the form of a pyramid. One must have comprised a bushel or more of small stones; the other was not so large. By patient watching the fact was discovered that these mounds were made by chubs, which could be seen carrying the pebbles in their mouths from near the water line to the hillocks. They worked incessantly and perseveringly, seeming unconscious of the presence of spectators. If driven away by dropping a stone upon them, they would quickly return and resume operations, always in nearly the same place, going over the same line to the same place to find the small stones.

The writer then asks for information regarding the purposes of the mound, etc. After commenting upon the uncertainty of the identity of the fish, the Forest and Stream expressed a wish that it had a specimen. In the issue of the same paper of December 22, 1881, p. 412, a note entitled "Mound-Building Fishes" stated that a specimen had been sent to Prof. G. Brown Goode for identification and he had decided that it was *S. bullaris*.

In the Geographical Journal, July, 1897, Dr. Robert Bell, in a paper on exploration to the south of Hudson Bay, said that:

> Chubs are called "awadose" (stone carriers) by the Indians from their habit of collecting gravel and stones, weighing from less than 1 ounce to about a pound, and depositing them in a heap in the bottom of a river as a suitable spot for hatching their eggs, which are placed in their singular nest. This is done in the spring. A larger or smaller number of fishes, whose bodies would weigh from a pound to 3 or 4 pounds, work together to build the nest, the size of which will depend upon the number of workers. They pick up the stones with their mouths and bring them to the heap, one at a time, from far and near. These nests are made in tolerably shallow water where there is a moderate current, which favors the hatching of the ova. Their form is generally conical, and they contain on an average a cartload of gravel and stones, but they vary from a wheelbarrow load up to 4 or 5 tons. The fact that the stones weigh fully one-third less under water than in the air helps to account for their ability to carry the larger ones, which may be seen in hundreds of these heaps.

In the American Naturalist for May, 1907, Dr. Alfred W. G. Wilson writes about these chub nests with several photographic illustrations, but stated that while the Indians and others maintain that the chub does the work he had been able to find no one who has seen the fish at work. But one would infer that Dr. Bell or some of his informants had seen the fish at work, as he stated definitely that they work several together and carried the stones in their mouths.

In Maine Woods, June 26, 1908, in an article on the chub, the writer stated that on several occasions he had seen chubs at work on such nests, but to the best advantage in June, 1907, at Whites Bridge, Sebago Lake. When standing on the bridge at some height above the water, everything on the bottom could be seen plainly. He watched one chub off and on for several days, and during that time the chub was never idle, always carrying stones to the heap or driving off other fishes. The other fishes in the vicinity of the nest were black bass, suckers, perch, shiners, and other chubs. The chub avoided or else did not mind the black bass very much. The bass, however, would seldom approach the heap, excepting when a school of shiners would swim over it, when one or more bass would dart at them. That which promised to be a valuable natural history observation was destroyed by some one catching the chub.

In the previously mentioned Putnam collection were specimens of chubs from Richardson Lake. On October 17, 1900, and October 28, 1904, the writer collected small ones in a minnow trap in Oquossoc Lake. During July, August, and September many were caught, from young only 2 or 3 inches long up to 13 inches long, in Umbagog Lake, Swift and Dead Cambridge Rivers, and Androscoggin and Magalloway Rivers. (See Table III, p. 591.)

BLACKSPOT CHUB (*Semotilus atromaculatus*).

Although a very commonly distributed fish in Maine, there was no record of its occurrence there until it was found at Freeport, Me., in 1892 and 1893.[a] It was subsequently found in many other localities. Only in one or two instances were any distinctive common names applied to it. At Green Lake it was called mummy-chub and at the Connecticut Lakes in New Hampshire it was designated as mud-chub. The name blackspot is applied to this fish in allusion to the black spot at the base of the anterior end of the dorsal fin. Its geographical distribution is given in "Fishes of North and Middle America" as Maine and western Massachusetts to southern Missouri, Wyoming, and Canada, chiefly in small brooks, where it is often the largest and most voracious inhabitant.

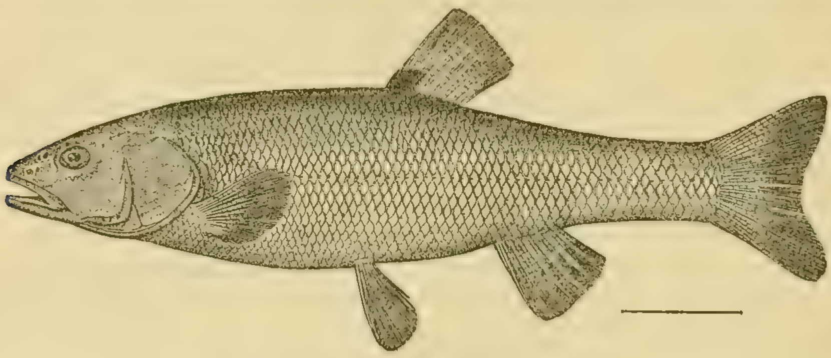

FIG. 5.—Blackspot chub (*Semotilus atromaculatus*).

It does not attain so large a size as the common chub; in New England it reaches a length of not over 10 inches, so far as is known, but averages considerably less.

This chub spawns in early summer, at which time the body of the male becomes of a darker hue and the pectoral and ventral fins are often a bright orange color, and there are horny excrescences on the snout and top of head. The nesting and breeding habits are described by Prof. Jacob Reighard in great detail[b] and illustrated by reproductions of photographs taken under water. These habits are very similar in many respects to those of the common chub. The upright position assumed by the female in spawning indicates that the common chub in the position described by Atkins was during the act of spawning, although nothing was noted regarding the position of the male as described by Reighard.

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[a] Kendall, W. C., and Smith, Hugh M.: Extension of the recorded range of certain marine and fresh-water fishes of the Atlantic coast of the United States. Bulletin, U. S. Fish Commission, 1894 (1896), p. 17.

[b] Bulletin, Bureau of Fisheries, Vol. XXVIII, 1908, pt. 2 (1910), p. 1111–1136.

The blackspot chub, while comparatively numerous in the smaller ponds and some of the streams, seems to be rather scarce in the lakes so far as collections indicate. On October 21, 1904, one was caught in a minnow trap at Mountain View Wharf in Oquossoc Lake. This is the only record for the lakes, but during July, August, and September numerous specimens were taken at Sluice Dam in Dead Cambridge River and at the dam in Swift Cambridge River. It was particularly abundant in York and Molnichwock Ponds and in the Swift Cambridge River at Grafton. The two largest specimens secured were 6½ and 7 inches long, respectively, taken in Molnichwock Brook.

CHUB MINNOW (*Couesius plumbeus*).

There seems to be no distinctive common name for this fish other than the above, which was coined to supply the deficiency. The name seems properly applicable, since the fish is a minnow closely related to the common chub.

This species, a few years ago recorded only from Lake Superior, is now known to be common throughout northern New England and occurs in almost every lake, pond, river, and brook in Maine. Putnam collected it in Metallak Brook and Richardson Lake, and the author got some in Oquossoc Lake in 1904. It was found in both Swift and Dead Cambridge Rivers and in Molnichwock Pond in 1905.

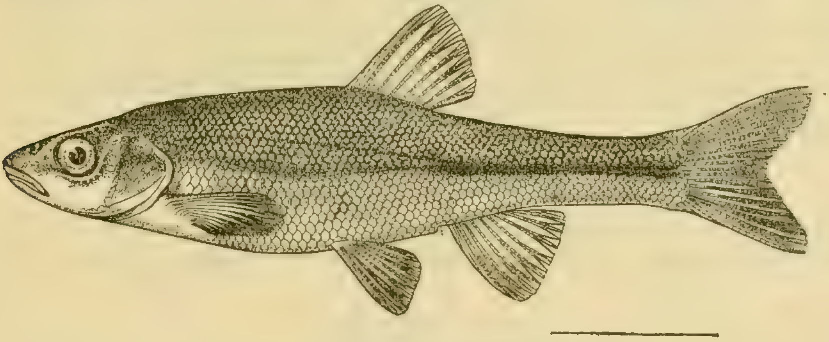

FIG. 6.—Chub minnow (*Couesius plumbeus*).

The chub minnow feeds chiefly upon animal food, as insects, etc. It also eats small fishes.

Its breeding season in the Rangeley Lakes region was not ascertained, but in some lakes in Maine where it ascends brooks to spawn it does so in May. It was found breeding in the Connecticut Lakes brooks in early July. In breeding season, in some waters at least, the scales of the entire body are margined with a series of fine tubercles or so-called pearly bodies.

This fish may be readily caught with baited hook and frequently with small fly. It is an excellent live bait.

BROOK SHINER (*Rhinichthys atronasus*).

This species of dace does not lack for local names. Its book name is blacknose dace, and it is variously called rock minnow, brook minnow, rock shiner, pot belly, pottle belly, etc. The last two names are derived from the frequent distended appearance of the abdomen due to tapworms, with which the fish seems to be extensively affected.

Its geographical range is extensive, and the fish is found in almost every brook and in some lakes and ponds from New Brunswick and Quebec south to northern Alabama and west to Minnesota. It feeds mainly upon insects, especially their aquatic larvæ, and entomostracans. It breeds in late spring and early summer.

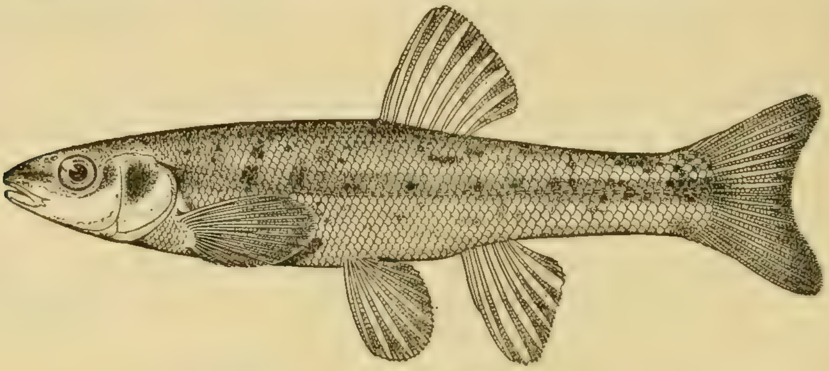

FIG. 7.—Brook shiner (*Rhinichthys atronasus*).

The only specimens collected in 1905 in this region were a few young and medium-size ones in the Dead Cambridge at and above the sluice on July 22 and August 21. In the Boston Society of Natural History's Museum are some specimens collected in Parmacheenee Lake many years ago.

BRONZE MINNOW (*Phoxinus neogæus*).

Prior to its discovery in New Brunswick in 1888 and again in 1895 by Philip Cox,[a] this species had not been recorded east of Wisconsin and Michigan. It was found by the writer in the East Branch of the Penobscot waters, Allagash Lake and Eagle Lake[b] in 1901 and in Indian Stream,[c] a tributary of the Connecticut River in northern New

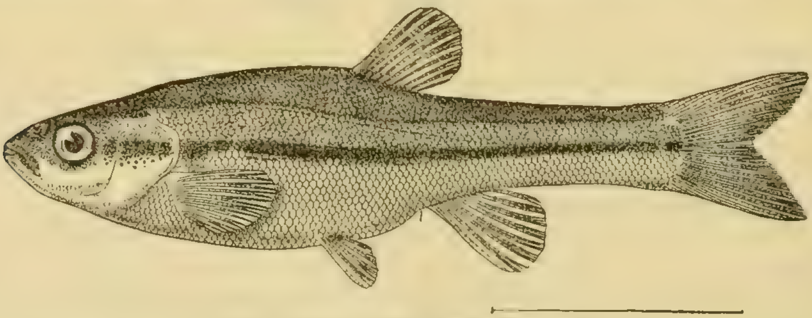

FIG. 8.—Bronze minnow (*Phoxinus neogæus*).

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[a] History and present state of the ichthyology of New Brunswick, with catalogue of its fresh water and marine fishes, Bulletin No. XIII, Natural History Society of New Brunswick, 1895, p. 44.

[b] Notes on some fresh-water fishes from Maine, with descriptions of three new species, Bulletin, U. S. Fish Commission, Vol. XXII, 1902 (1904), p. 356.

[c] The fishes of the Connecticut Lakes and neighboring waters, with notes on the plankton environment. Bureau of Fisheries, doc. no. 633, 1909, p. 29.

Hampshire, in 1904. On July 22 a few specimens were taken at the sluice, on the Dead Cambridge River.

It is a handsome little fish, attaining about 4 inches in length. It feeds upon small insects, eggs, larvæ, worms, and vegetable matter. It makes a good bait and will readily take a small hook baited with worm. Nothing regarding its breeding habits was observed, but it probably spawns in the spring or early summer.

REDFIN (*Notropis cornutus*).

The redfin or redfin shiner derives its name from the red fins of the breeding male. The name is, therefore, not always individually applicable and is not distinctive, as other cyprinids, as well as other fishes, have red fins at times, and this species does not always have them.

The distribution of the redfin is very extensive, according to Jordan and Evermann, inhabiting the entire region east of the Rocky Mountains except the South Atlantic States and Texas. In 1900 and 1904 it was collected in Oquossoc Lake and in Umbagog Lake in 1905, also in the Dead Cambridge River and the Androscoggin River near the mouth of Molnichwock Brook.

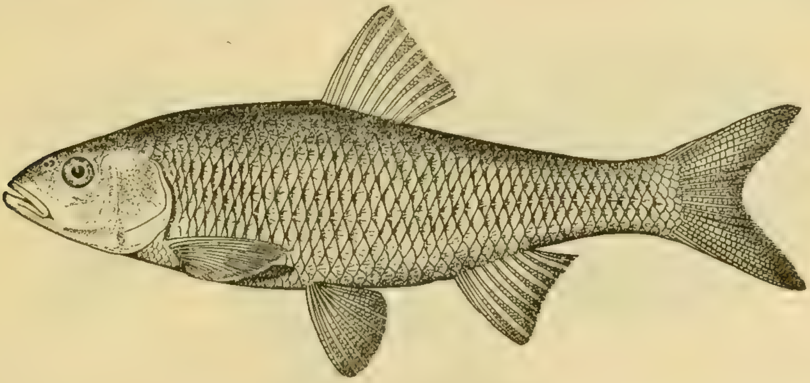

FIG. 9.—Redfin (*Notropis cornutus*).

The redfin attains a length of 8 inches. Those secured in Oquossoc Lake, October 17, 1900, ranged from $3\frac{7}{10}$ to a little over 5 inches in length, and those from the other waters in 1905 from 3 to 4 inches. (See Table IV p. 591.) The fish is carnivorous, feeding largely upon insects and their larvæ and to some extent, especially in its youthful stages, upon entomostracans. In lakes and ponds the redfin lurks around water plants, where its food is most abundant, but on calm evenings it moves about in schools at the surface over deep water, far from shore, feeding upon insects that have fallen upon the water.

Its breeding time is in the spring or early summer, according to the temperature of the water. At this time the male assumes a beautiful coloration, the fins broadly margined with bright red, the back an iridescent blue, and the sides reflecting all the hues of the rainbow. The head of the male at this time bears conical horny tubercles or excrescences, whence the names horny-head and buckfish.

The redfin will readily take a hook, especially if baited with earthworm, and is also caught on small artificial flies, especially when feeding upon insects at the surface. The fish is one of the best of live baits.

The proportional measurements of Rangeley Lakes specimens differ somewhat from Connecticut Lakes specimens. The Rangeley Lakes specimens average somewhat smaller than those of the Connecticut Lakes and are, therefore, somewhat more slender. The head is proportionally somewhat shorter. Whereas the eye in the smaller fish should be proportionally larger, in the Rangeley fish it is somewhat smaller than in the larger Connecticut Lakes specimen. The snout is considerably shorter. The longest ray of dorsal, which should be proportionally higher than in the larger fish, is considerably lower. The dorsal and anal fin ray counts are the same, but the scales average one more than in the Connecticut Lakes specimen, although the latter comprise some 42 scales.

SHINER (*Notemigonus crysoleucas*).

Other Maine names of more or less restricted use for this fish are pond shiner, bog shiner, and herring.

The recorded range of the species is from Nova Scotia and Maryland to Dakota and Texas—everywhere abundant in bayous and weedy ponds. It was not found at all in the Connecticut Lakes and only in the lower part of the Rangeley chain, although it probably occurs to some extent in the upper waters. A great many were taken in Umbagog Lake, the largest being not over 5 or 6 inches long. They were most frequently found at the mouth of brooks in water about 3 feet deep where aquatic vegetation was abundant. As usually observed, it seldom is over 5 or 6 inches long, but in some waters it attains a length of 1 foot or more.

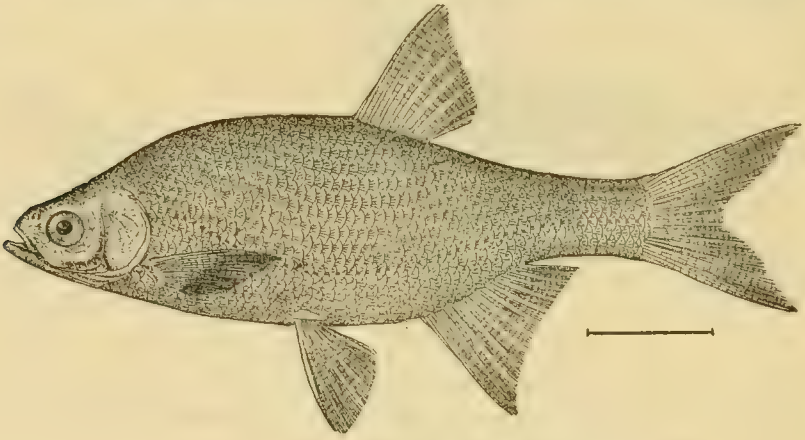

FIG. 10.—Shiner (*Notemigonus crysoleucas*).

This fish subsists mainly upon insects and entomostracans. It is a most excellent bait fish. Being so abundant in Umbagog Lake, it must contribute largely to the food supply of pickerel.

EEL (*Anguilla rostrata*).

There is no other common name for this fish except some which apply to different sexes, ages, or appearances, such as silver eel, broad-nose eel, sharp-nose eel, etc.

The distribution of the eel on the Atlantic coast and in the inland waters of eastern North America is very extensive, ranging from as far north at least as the St. Lawrence and south to the Gulf of Mexico and West Indies. It ascends, as young fish, all rivers within its range, often to the very sources, from whence, to breed, it descends to the sea.

It does not seem to be very common in the Rangeley region, which is fortunate, as it is rather destructive to other fishes. It was not observed by the United States Bureau of Fisheries' party in 1905. The only records appear to be those of the State Fish Commission Report for 1878, which is here quoted: "Three eels which had forced themselves through a leak in the gate of the Upper Dam were killed by the weight of water driving them between the logs of which the aprons of the dam are built. These eels were weighed by Thomas McLeod, a strictly reliable man. Their weights were, respectively, 8½, 11½, and 13¾ pounds." In American Angler, April 14, 1883, J. G. Rich wrote: "Large eels have been picked up on this dam measuring 4 or 5 feet, yet we never have caught one in the lake above." In Forest and Stream, November 24, 1900, J. Parker Whitney said that large, lusty, white and yellow bellied eels were found in the lakes, but not very plentifully, and that he had never known them to be caught with bait. He said that he had seen a few weighing from 10 to 12 pounds that were caught fast in the narrow space between the logs of the apron below Upper Dam during the night passage from the lake above. Both of these statements doubtless refer to the same record mentioned in the State Fish Commission Report.

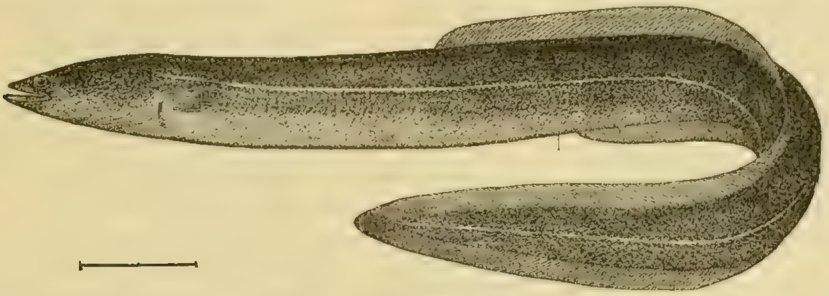

FIG. 11.—Eel (*Anguilla rostrata*).

WHITEFISH (*Coregonus clupeaformis*).

This whitefish is one of the numerous species constituting a subfamily of the Salmonidæ, widely distributed in the northern waters of both hemispheres.

In appearance the whitefishes are distinguished from the rest of the salmon family by having a comparatively small mouth, feeble dentition, and comparatively large scales. They are inhabitants of many of the larger and deeper lakes throughout their geographical range. Some species attain to a weight of over 10 pounds while others to only a few ounces. The different species have somewhat different feeding habits, but, as a rule, nearly all subsist upon the smaller lacustrine animal life, including fishes and in some instances insects that fall upon the water.

Some forms breed on the shoals of lakes, to which place they sometimes migrate considerable distances in the fall of the year; others ascend streams for the purpose of spawning.

All are excellent food fishes, and the present form is highly esteemed.

While there are three species common in many Maine lakes, especially north and east, not one of these is indigenous to the Rangeley Lakes. The native Maine form closest to this species is usually very abundant wherever it occurs. In some waters its average size is about 1 pound, for which reason, many years ago, it was denominated "poundfish." In some northern Maine waters individuals weighing as much as 6 pounds have been observed. In some localities it is called whiting and in some other New England waters it is erroneously called shad. Among the Canadian French of northern Maine it is known as pointeur and poisson pointu and in other places as poisson blanc.

It subsists largely upon small crustaceans, aquatic larvæ of insects, and small fishes, such as occur in the depths inhabited by whitefish, but it very frequently approaches the surface and feeds upon insects that have fallen upon the water.

It is an excellent food fish, but is not usually regarded as a game fish. The usual methods of capture have been by seining during the spawning runs and with bait through the ice. Yet it has been taken on an artificial fly and by trolling. Upon a light rod and small fly it affords excellent sport, especially in streams, where it may sometimes be caught even in the summer.

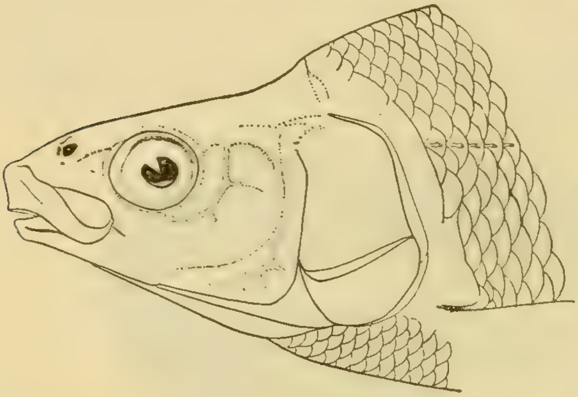

FIG. 12.—Head of Umbagog Lake whitefish (*Coregonus clupeaformis*).

The whitefish of Umbagog is the result of a plant made by the Maine fish commissioners in Oquossoc and Mooselucmaguntic Lakes in 1881, regarding which the Maine Fish Commission Report for that year has the following:

> We were presented by Prof. Baird, from the establishment of Frank N. Clark, Northville, Mich., 1,000,000 whitefish eggs. Owing to the extreme cold weather, long distance of transportation, and tenderness of the eggs, the percentage of loss was large. Should judge about 25 per cent of the eggs hatched. They were received in February; were hatched and turned loose March 20. About 15,000 of these were put in Rangeley, the balance were turned loose in Mooselucmaguntic Lake.

The only possible indication of its subsequent appearance in the upper lakes is the statement of a resident of Rangeley, who told the writer in 1904 that he knew of one, and only one, having been taken in Oquossoc Lake, about three or four years before. In the winter of 1903 it was first detected in Umbagog Lake by Capt. Dana Brooks, of Upton, when fishing for pickerel near Metallak Island. Capt. Brooks subsequently informed the writer that the fish were taken on small fish bait, and some were caught in that way every winter.

H. O. Stanley, then a member of the Maine Inland Fish and Game Commission, had several of these fish sent to the Bureau of Fisheries, with the statement that they were the first evidences of the results of his plant in 1881.

There is some uncertainty regarding whether or not the present form is specifically identical with the common Maine whitefish, formerly known as *Coregonus labradoricus*. A comparison of the specimens from Umbagog Lake with native Maine whitefish of like and diverse sizes reveals some slight but, so far as these specimens are concerned, constant structural differences. The same differences obtain between specimens from Lake Michigan and the Maine fish. While these differences are slight, the characteristics presented by the Maine fish persist in a large number that have been examined.

Whether or not those of the Michigan fish are constant can be told only by an examination of a larger number of specimens. In certain proportional measurements the Umbagog fish approaches the Maine fish, intergrading or interlinking the Michigan with the Maine form, suggesting that the change to the conditions of environment found in Maine is correspondingly modifying the fish and thus indicating that the differences between the Michigan and Maine fish may be merely ontogenetic. In the dim light of our present knowledge, however, it seems best to continue to regard the native Maine form as a distinct species, although the geographical limits of either form are unknown.

The most conspicuous and about the only distinct differences shown by the specimens examined are in the shape of the head and form of some of the head bones. In the Umbagog fish, as well as those of the Michigan waters that have been examined, the supraoccipital and parietal bones slope from the nape to the frontals, forming a somewhat concave profile, figure 12. In the Maine fish the profile is always straight and continuous with the line of the nape, figure 13. In the Umbagog fish the opercular bones are proportionally deeper and the supplementary maxillary proportionally longer and narrower than in the Maine fish, and the lower jaw of the Umbagog fish is slightly shorter than in the Maine fish.

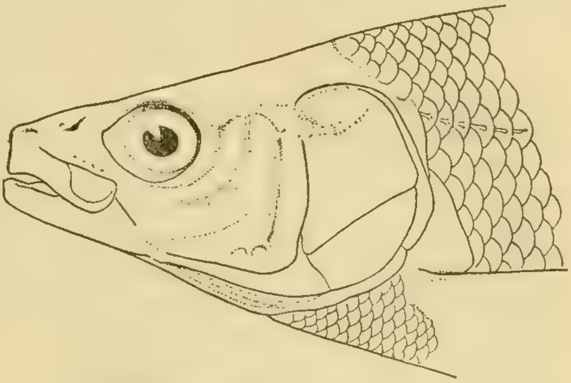

FIG. 13.—Head of Maine whitefish (*Coregonus labradoricus*).

The following comparison of averages of proportional measurements of the Umbagog, Maine, and Michigan fish, respectively, in many instances shows the previously mentioned intergradation:

Head of Umbagog fish longer than that of the Maine fish and slightly longer than that of the Michigan form.

Maxillary, longer than Maine and Michigan, the latter two essentially alike.

Mandible, shorter than Maine, about the same as Michigan.

Snout, shorter than Maine, intergrading with Michigan.

Interorbital, essentially the same in all.

Eye, about the same as Maine, but somewhat larger than Michigan.

Depth, about the same as Maine; less than Michigan.

Longest dorsal ray, about the same in all.

Longest anal ray, longer than Maine, shorter than Michigan.

Pectoral, longer than Maine, shorter than Michigan.

Ventral, longer than Maine, shorter than Michigan.

Longest gill raker compared with eye, longer than Maine, shorter than Michigan. (See Table V, p. 592.)

The number of gill rakers is somewhat greater than in the Maine fish and somewhat greater than in the Michigan form, overlapping both, but the latter more than the former. The increase in the average number of gill rakers does not indicate that the fish is adapting itself to coarser food, as the fact that it takes a small fish bait suggests, but rather that its principal subsistence consists of more minute forms. This, if a fact, perhaps will account for it disappearing from the upper lakes and more or less permanently abiding in Umbagog, where the plankton is more abundant.

Why it should descend the Androscoggin as far as Berlin with the apparent intention of going farther is an unanswerable question.

Elmer Bean, of Berlin, N. H., informed the writer that some years ago two specimens of whitefish were found in the grate of the flume of a pulp mill at Berlin and that he had frequently caught them on bait at the mouth of Molnichwock Brook. In 1905 one, 12⅜ inches long, was taken by the Bureau of Fisheries' party in a gill net in the deep hole off Sunday Cove August 17, and one, 16 inches long, was caught on a hook and line at the mouth of Molnichwock Brook July 17.

SEA SALMON (*Salmo salar*).

The Atlantic salmon, sometimes designated as sea salmon to distinguish it from the fresh-water or so-called landlocked salmon, is a resident of the north Atlantic along the coasts of Europe and America, ascending all suitable streams. In Maine the Androscoggin was one of a number of rivers formerly ascended by the salmon, but owing to impassable falls it never reached the Rangeley Lakes. The only interest attached to this species so far as those lakes are concerned is in the fact that a number has been introduced there from time to time and the possibility of their having contributed to the salmon stock of the lakes. The following plants were made: Ten thousand fry in 1873; 99,000 fry in 1881; 194,600 fry in 1882; 1,000 yearlings in 1900–1901.

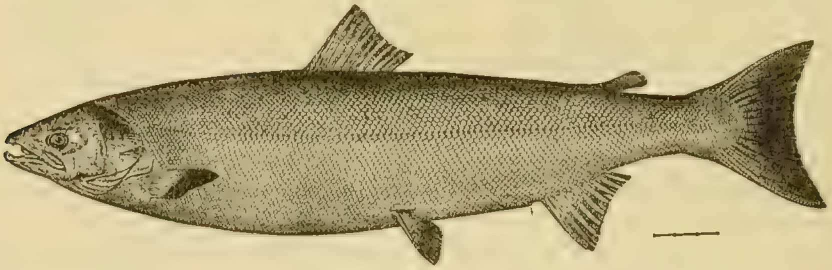

FIG. 14.—Sea salmon (*Salmo salar*).

The differences by which this species can be distinguished from the landlocked salmon are slight and by the ordinary observer would probably not be noticed. The most conspicuous external characteristics are the smaller, more pointed head, more slender caudal peduncle, more numerous scales,[a] and radical difference in color in the adult sea salmon. So far as relates to the desired or undesired result of its introduction into these waters, its distinguishing characteristics are of little moment now. The desired result was to furnish fish for the angler. To him its structure is of no concern so long as its size and gameness are satisfactory, its table qualities being equal to those of the other species. The undesired results are its effects upon other fishes. Its feeding habits in these waters probably would not differ from the landlocked salmon, and its effects upon the game fishes would likely be the same as in the case of the landlocked salmon.

The first salmon caught of which there is any record was taken in 1875 and weighed one-half pound. This might possibly have been from the plant of Schoodic salmon of 1874, but that is a pretty good growth from fry in one year. Another weighing 2 pounds was taken in 1876. Both of these were possibly sea salmon.[a] No more were taken until 1880, when one of 4 pounds was recorded; but it can not be positively ascribed to the sea-salmon plant, for the Schoodic salmon planted in 1875 and 1876 had five and four years, respectively, in which to reach that size.

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[a] There is some doubt about this character.

The two salmons weighing 6 and 12 pounds, respectively, taken in Mooselucmaguntic Lake in 1882 might have been from the plants of either sea or Schoodic salmon, but the 79 caught at Middle Dam in the same year, weighing up to $4\frac{3}{16}$ pounds, averaging $1\frac{2}{3}$, were some of the landlock stock.

No more salmon, so far as records show, were caught in any of the lakes until 1887. The records for that year were one of $7\frac{1}{2}$ pounds in Rangeley Lake and one of 5 pounds from Richardson Lake. Thus it seems that the survivors of the original stock of sea salmon had then all disappeared.

SALMON (*Salmo sebago*).

In fish culture this fresh-water salmon is otherwise known as landlocked salmon, Schoodic salmon, and Sebago salmon, and in local parlance in some places is designated as salmon trout and blackspot to distinguish it from the common trout (*Salvelinus fontinalis*). Landlocked salmon is a misnomer. It is, moreover, not euphonic, and long custom alone partly justifies its use. Fresh-water salmon would be more appropriate.

In Maine its natural waters were restricted localities in the St. Croix, Union, Penobscot, and Presumpscot River Basins. It, or a kindred form, occurs naturally also in a few lakes of New Brunswick and Nova Scotia, and an apparently distinct but closely related species is found in the Saguenay River Basin in Quebec. The claim that it occurs in Labrador is somewhat uncertain and perhaps based upon mistaken identification. Yet there is no apparent reason why it might not be found there.

This salmon subsists upon insects and fishes, particularly upon smelts. In fact, in its native waters its existence seemed to depend in some way upon the presence of smelts, and in other waters it thrives only where the smelt has been introduced.

The spawning, as a rule, takes place in November, and the eggs hatch the following spring. In most instances, if possible, salmon ascend or descend streams to spawn upon gravelly bottoms in quick-running water. When such streams are not available, the operation takes place on gravelly shoals of the lake, but it is doubtful if in such places the process amounts to much. In the breeding season there are more or less structural and chromatic changes in the fish. The jaws of the male are prolonged, the under jaw becomes hooked, owing to a knoblike cartilaginous proliferation that fits into a socket in the snout, but in some cases passes up, over, or through the end of the snout. The colors of both sexes become brighter, brown, orange, yellow, and blue appearing on the bodies, especially the male, and occasionally faint orange spots on the tail, which at other times is spotless. The salmon practically cease feeding at this time. They probably do not breed oftener than every other year. The age of maturity is probably about 4 years, although some individuals are more precocious and some are retarded more or less.

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[a] In the Transactions of the American Fish-Cultural Association for 1883, p. 49, without giving the year, Atkins stated that about 50 domesticated Schoodic salmon about 2 years of age were introduced. This might have been prior to the 1873 plant of sea salmon.

The young salmon, after it is able to swim and feed, whenever possible, like the young of the sea salmon and the common trout, enters small brooks tributary to the spawning stream in the vicinity of the breeding place, and always little salmon a few inches in length occur on the rips and in shallow eddies and pools of the breeding stream, which suggests that, other conditions being favorable, such places should be selected in which to plant young fish, whether fry or fingerlings, rather than to place them directly in the lake.

The records of plants are very incomplete and otherwise unsatisfactory. There are no available records of the number planted by private clubs and angling associations. The State reports often lack some element of a complete record. Very often the number is not given. It is very difficult to assign the plants of some of the reports to the proper years. The later State reports, published every two years, usually give the records for one year only—that of the report. Sometimes it is difficult to know which pond is meant, in that the records for ponds are very incomplete, a number of ponds in the State bearing the same name.

From the viewpoint of recent years it seems somewhat astonishing that, though the larger lakes were stocked with the salmon, some of the smaller ponds were not left to the trout. Instead, however, almost every little pond in the region has received some landlocked salmon. The earlier introductions were usually fry, and in later years the majority were fingerlings, with some yearlings.

PLANTS OF SALMO SEBAGO IN THE RANGELEY LAKES.

1875	5,000	1898	4,000	1907	136,000
1876	3,000	1899	2,000	1908	176,000
1877	18,000	1900	65,000	1909	184,937
1881	18,750	1901	3,014	1910	60,137
1883	198,000	1902	14,500	1911	124,500
1884	153,000	1903	12,000	1912	(a)
1895	(a)	1904	234,015	1913	82,000
1896	(a)	1905	900	1914	37,500
1897	4,800	1906	24,000		

INCREASE IN NUMBERS AND RATE OF GROWTH.—It has always been assumed that, other things being equal, the rate of growth, as well as the size attained, by any fish depended upon its food supply. Atkins said (loc. cit.) that when introduced into new haunts the salmon has often grown to an unwonted size and sometimes at an accelerated rate. The records show that at the Rangeley Lakes salmon of considerable size were not taken in large numbers until after the introduction of smelts, although large individuals were occasionally caught. The food supply must have been mainly the fishes already occurring there and to a great extent, no doubt, the little blueback, which rapidly disappeared as the salmon increased in numbers. The smelt was introduced too late to save them. From the year following the introduction of smelts there was a progressive, though fluctuating, increase in numbers of salmon but no great variation in the average weight. The average weight, as shown by the records, however, decreases to some extent as the number caught increases.

Forest and Stream, July 22, 1875, contained the following notice:

> A lady caught at the mouth of the Rangeley River a landlocked salmon weighing a half a pound, the first ever captured in this vicinity, and probably the first returns of the salmon fry put in at Kennebago Rapids by the Maine Fish Commission in the spring of 1873.[b]

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[a] No records.

[b] Referred to under sea salmon.

Again, in the same paper, June 8, 1876, it was reported that a 2-pound landlocked salmon was caught about the same time from Rangeley Stream, "the first stranger of any size that has been caught from the recent importations into these waters." This paper reported in its issue of June 7, 1877, that several salmon, weighing from 1 to 4 pounds, had been taken, and on August 19, 1880, five were reported, the largest of which weighed 4 pounds.

The American Angler, July, 1882, contained a statement to the effect that at noon on July 2 a landlocked salmon weighing nearly 4 pounds was taken in swift water below the dam (Middle Dam). This was the largest one ever taken there.

Commissioner H. O. Stanley reported to Forest and Stream, October 26, 1882, as follows:

> I am very happy to say that the salmon put in an appearance in the Rangeley Stream for the first time. Some of them were very large. I saw five of them in a pool, which I estimated would run from 4 to 10 pounds each. They have also been taken in the lakes below. For the short time that has elapsed since they were introduced and the small number of eggs this increase has been remarkable.

In American Angler, April 14, 1883, J. G. Rich, writing of record trout, said that at the same time there were also taken many landlocked salmon, the plant of which was made about five years previously, the fish weighing from 5 to 10 pounds. The same paper, July 24, 1884, stated that a 5-pound salmon had been taken from Umbagog Lake, and that a large one had been hooked and lost in Mooselucmaguntic Lake. This paper, November 25, 1886, contained the statement that in the previous September, while fishing in Rapid River opposite the old Oxford Club House, a landlocked salmon that had two rows of red spots on each side and two others that had only black spots were caught. On May 22 of that year four salmon weighing, respectively, 3, 8, 9, and 11 pounds were reported. In Forest and Stream, June 3, 1886, a correspondent wrote that the showing up of landlocked salmon in the Androscoggin Lakes that spring had established a happy fact for anglers and a triumph in fish propagation very gratifying to everybody, and more especially to the worthy fish commissioners of the State, who had labored so arduously in that direction.

Writing of Rapid River in American Angler, February 6, 1886, J. G. Rich stated that fishermen reported the taking of a great number of trout and salmon 8 or 10 inches long, about the same number of each kind.

Forest and Stream, May 26, 1887, stated that it was worthy of note that trout scores of the early arrivals at Rangeley Lake were sprinkled with landlocked salmon, and the American Angler, June 11, of the same year, stated that in addition to trout they then had a fair quantity of landlocked salmon. Hardly a day passed without one or two being brought into camp, weighing 2 pounds on an average, while much larger ones were often seen and taken, and it was thought that the day was not far distant when there would be a plentiful supply of this variety. The same paper, June 30, of that year, said that there were numerous reports of the capture of landlocked salmon in the Upper Androscoggin Lakes, particularly Rangeley Lake. The catches of trout were said to be sprinkled now and then with a salmon or two. But there was no report of any in the lower lakes of that chain for that season.

A Philadelphia correspondent of Forest and Stream, October 13, 1887, established a record of salmon taken on a fly as follows:

> It may interest the readers of Forest and Stream to learn that on Monday, September 26, I took a landlocked salmon in the Rangeley Lake (near the end of the lake at Greenvale) which weighed 7½ pounds. I used an ordinary 7-ounce fly rod, small linen line, 6-foot leader, dark Montreal, and a light-colored fly, the latter being the drop, which he took in a manner that showed that he meant business. * * * This is said to be as large a salmon as was ever taken from the Rangeley Lakes with a fly.

Forest and Stream, May 31, 1888, stated that considerable success was noted that spring in taking landlocked salmon in Rangeley Lake. One of 5 pounds and one of 6½ pounds were reported as well as a large number of smaller sizes. The report continued:

> It is worthy of note, however, that although these landlocked salmon have been planted in the other lakes of the Androscoggin chain, and that these lakes are all connected by quite respectable rivers in point of size, yet but very few salmon have been taken other than in Rangeley Lake.

In the same paper, a communication dated May 25 stated that parties were catching more landlocked salmon than ever before.

The report of each succeeding year indicated an increase in number and size of salmon, also their gradual appearance successively down the chain of lakes. Forest and Stream, July 30, 1891, stated that it was quite evident that the introduction of landlocked salmon into the Maine lakes was going to be a success. But, as shown elsewhere, there appeared no positive and definite salmon records for 1892, 1893, and 1894. Reference to fish were, in all probability in part at least, to salmon, but owing to the element of uncertainty such indefinite accounts are not here included.

Forest and Stream, July 24, 1897, contained a communication, dated July 12, in which it was recorded that Prof. S. R. Morse, of Atlantic City, N. J., took a 13½-pound salmon "the largest landlocked salmon ever taken with hook and line from Rangeley waters." Another angler, about the same time, took one of 12 pounds. Both were caught in Upper Rangeley, or Oquossoc Lake. Up to this time the majority of the salmon had been caught in the upper lakes, particularly Oquossoc. Forest and Stream, May 28, contained the following notice:

> In the pool below the dam (Upper Dam) a number of salmon have been taken. This is all the more remarkable when it is remembered that only a few have ever been taken there before, though a good many have been taken in the lakes above.

Yet a continuous increase is evident and became pronounced in 1896. From then on the references are not, as hitherto, from the interest in a few salmon taken but to the large catches and large size of the fish. In Forest and Stream, July 11, 1896, a correspondent wrote:

> The landlocked-salmon record at Rangeley, already referred to, is a remarkable one. The first 21 salmon taken by guests of the Rangeley Lake House, and almost within sight of the house, actually weighed 135 pounds 2 ounces, an average of 6 pounds 7 ounces to the fish. Fifteen of the same fish weighed 112 pounds 14 ounces, an average of 7 pounds 8 ounces. The catch of the above fish began May 7 and ended June 4. A great many large salmon have also been taken since.

The predicted success of the introduction of landlocked salmon into the Rangeley Lakes seems to have been consummated. In 1900 Forest and Stream, July 7, noted: "Never before has Rangeley Lake seen such excellent fishing." The fish caught were all salmon. In 1901, under date of May 26, a note from Upper Dam read: "A remarkable feature is that almost as many salmon are being taken as trout. * * * While the supply of trout has scarcely lost anything, a supply of salmon has been added." A record of the catch by guests of the Rangeley Lake House on June 5 consisted of 17 salmon but not a single trout.

In 1906, the year of the largest catch of salmon in the Rangeley Lakes, during the week up to May 30, the records of the Rangeley Lake House showed 34 salmon and 3 trout. In Maine Woods a comparison of two weeks fishing during the last of May and June, 1905 and 1906, was made as follows: 1905, 53 trout and salmon weighing from 3 to 8¼ pounds; 1906, 74, of which 5 were trout, the largest 5½ pounds, the largest salmon 9 pounds. The paper stated that this was the best record ever made by guests of the Rangeley Lake House. Another score was reported covering the time from May 15 to July 3, inclusive, consisting of 278 fish aggregating 1,147¾ pounds and averaging 4 pounds 2¼ ounces, with no fish under 3 pounds entered. Another report in the same paper stated that during July the guests of the same hotel had recorded 127 salmon and only 1 trout, which weighed 5½ pounds.

Size attained in Rangeley Lakes.—The largest salmon on record for Rangeley Lakes are one of 18½ and one of 17½ pounds, taken by State fish culturists in 1905. The largest taken by an angler was one of 16½ pounds, caught by George T. McNeil,[a] a Boston Pullman-car conductor, in 1903. There are two records of 13½-pound fish, one in 1897 and the other in 1911. One of 12$\frac{9}{16}$ pounds was taken in 1902; three of 12½ pounds in 1898, 1903, and 1910, respectively; one of 12$\frac{1}{10}$ pounds in 1907; two of 12 pounds in 1882 and 1900, respectively; one of 11½ pounds in 1905; one of 11 pounds in 1886; one of 10¾ pounds in 1896; one of 10½ pounds in 1901; one of 10¼ pounds in 1908; and one of 10 pounds in 1899. The average weight for the last 10 years, up to and including 1912, was a little over 4¼ (4.26) pounds.

In 1915 the average weight as ascertained from 549 records ranging from 1 to 8½ pounds, was a little over 3½ (3.55) pounds.

CATCHES OF SALMON AND TROUT COMPARED.—It has been maintained by some that the trout decreased in numbers as the salmon increased, which opinion is to some extent supported by deduction from the following data:

In Upper Rangeley Lake, or Oquossoc Lake, the first salmon was caught in 1887, two more were taken in 1888, none is recorded for 1889 and 1890, and one is mentioned next for 1891. No more records appear until 1896, when 23 salmon are recorded but no trout. In 1897, 35 salmon, ranging from 3 to 13½ pounds, are recorded and 6 trout from 2 to 6½ pounds. In 1898, 45 salmon weighing from 3⅛ to 12½ pounds and 32 trout weighing from 2½ to 8½ pounds are recorded. The records for 1899 show 65 salmon, ranging in weight up to 10 pounds and averaging 4⅘ and 5 trout weighing from 3½ to 6¼ pounds, averaging 5 pounds. Of this catch, 92.86 per cent were salmon and 7.14 per cent trout. In 1900, 6 salmon ranging from 4½ to 12 pounds are on record but no trout. In 1901, 11 salmon weighing from 2 to 7½ pounds but no trout are recorded. In 1902, 11 salmon weighing from 3¼ to 10 pounds and 3 trout weighing from 3½ to 6¾ pounds are reported. In 1903 salmon appeared in considerable numbers but were followed by a big decrease in 1904. The records show also a decrease in trout, but from then on the numbers increased fluctuatingly.

The first salmon taken in Mooselucmaguntic, weighing one-half pound, and 9 trout were recorded in 1875. The following year 1 salmon of 2 pounds and 35 trout were recorded. No more salmon appear in the records until 1880, when a 4-pound one is mentioned with 18 trout. There are no records for 1881 for either trout or salmon. Two salmon of 6 and 12 pounds, respectively, and 203 trout are reported in 1882. No further salmon records appeared until 1891, when 2 are recorded and 11 trout. Then follow three years of no salmon records. In 1895 salmon reappear and increase gradually, with some fluctuation till 1912.

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[a] Forest and Stream, June 6, 1903, p. 468.

The number of trout decreased on an average but fluctuated greatly until 1910, when there was a large increase that was maintained and increased to 1912, but a larger number was taken in 1911 than in 1912.

The percentage of trout naturally decreased with the increase in number of salmon, but the later increase of trout suggests that the decrease was not alone due to the disproportionate increase of salmon but to actual decrease in number of trout, which the records of catches also, to some extent, indicate. A later increase in percentage of trout indicates some reestablishment, perhaps, but still shows a preponderance of salmon.

In Richardson Lakes, Molechunkamunk and Wellekennebacook Lakes, the first salmon were recorded in 1882, when 79, averaging 1⅖ pounds, were mentioned. No more records appear until 1887, when one 5-pounder was reported. The next year 2 of 3½ and 5 pounds, and in 1889 4 weighing from 3½ to 8 pounds were recorded. No records appear in 1890, but in 1891 one 6-pounder was reported. No more are given until 1898, from which year some were reported each year to 1912. The larges. number was caught in 1903, when 56 salmon and 137 trout were on record for the seasont The next largest number was in 1906, when 44 salmon and 25 trout were caught. In 1909, 38 salmon and 31 trout constituted the number appearing in the records. The records for three succeeding years were: 1910, 8 salmon and 19 trout; 1911, 6 salmon and 6 tout; and 1912, 10 salmon and 10 trout.

For the entire chain of Rangeley Lakes continuous salmon records do not appear until 1895. One was caught in 1875; 1 in 1876; 1 in 1880; 81 in 1882, against 236 trout; 7 in 1886; 2 in 1887; 4 in 1888; 4 in 1889; and 5 in 1891.

TABLE 4.—RESPECTIVE NUMBERS OF SALMON AND TROUT RECORDED FROM OQUOSSOC, MOOSELUCMAGUNTIC, AND THE ENTIRE CHAIN OF LAKES IN THE 21 YEARS FROM 1895 TO 1915, INCLUSIVE.

Year.	Oquossoc.		Mooselucmaguntic.		Entire chain.[a]	
	Salmon.	Trout.	Salmon.	Trout.	Salmon.	Trout.
1895	....	....	2	162	3	168
1896	....	....	4	10	37	10
1897	35	6	10	66	25	75
1898	45	20	23	180	71	242
1899	65	5	32	40	97	45
1900	52	....	56	27	63	29
1901	11	....	13	14	26	16
1902	11	3	89	47	108	56
1903	200	29	171	69	418	207
1904	28	5	69	7	100	13
1905	10	22	153	61	363	83
1906	374	18	172	52	590	95
1907	242	44	136	72	396	150
1908	301	9	100	56	415	80
1909	124	6	105	55	267	92
1910	214	42	243	108	465	163
1911	161	21	252	214	419	237
1912	245	34	292	126	547	170
1913	214	31	187	38	423	99
1914	149	18	248	94	405	124
1915	92	19	405	64	549	96

[a] Including Pond-in-the-River but not Umbagog. Apparent discrepancies in the total for each year of the entire chain when compared with the total for the individual lakes are due to the admission of general references to Rangeley Lakes, no particular lake being designated.

TABLE 5.—PERCENTILE PROPORTIONS OF SALMON AND TROUT, IN ROUND NUMBERS, FROM OQUOSSOC, MOOSELUCMAGUNTIC, AND THE ENTIRE CHAIN OF LAKES IN THE 21 YEARS FROM 1895 TO 1915, INCLUSIVE.

Year.	Oquossoc.		Mooseluc-maguntic.		Entire chain.[a]	
	Salmon.	Trout.	Salmon.	Trout.	Salmon.	Trout.
1895	....	....	2	98	2	98
1896	....	....	29	71	80	20
1897	85	15	13	87	25	75
1898	69	31	11	89	22	78
1899	93	7	44	56	68	32
1900	100	....	67	33	68	32
1901	100	....	48	52	61	39
1902	78	22	65	35	66	34
1903	87	13	71	29	67	33
1904	85	15	90	10	89	11
1905	90	10	71	29	81	19
1906	95	5	76	24	86	14
1907	84	16	67	33	72	28
1908	97	3	64	36	84	16
1909	95	5	66	34	75	25
1910	83	17	69	31	74	26
1911	88	12	54	46	64	36
1912	88	12	70	30	76	24
1913	87	13	83	17	81	19
1914	89	11	72	28	76	24
1915	83	17	86	14	85	15

[a] Including Pond-in-the-River but not Umbagog.

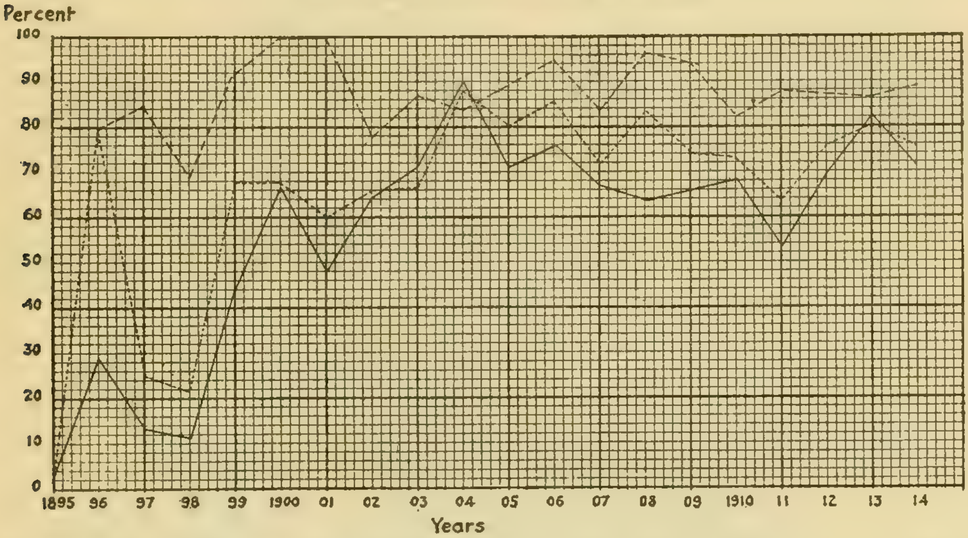

FIG. 15.—Percentile proportion of recorded numbers of salmon to recorded numbers of salmon and trout combined from Oquossoc, Mooselucmaguntic Lakes, and the entire chain of lakes, in the 20 years from 1895 to 1914, inclusive. Broken, line, Oquossoc Lake; solid line, Mooselucmaguntic Lake; dotted line, the entire chain.

TABLE 6.—RATIOS OF SUCCEEDING YEARS TO THE FIRST YEAR OF THE PERIOD OF 21 YEARS OF SALMON AND TROUT RECORDED FROM OQUOSSOC, MOOSELUCMAGUNTIC, AND THE ENTIRE CHAIN OF LAKES IN 21 YEARS FROM 1895 TO 1915, INCLUSIVE.

Year.	Oquossoc.		Mooseluc-maguntic.		Entire chain.[a]	
	Salmon.	Trout.	Salmon.	Trout.	Salmon.	Trout.
1895	([b])	([b])	100	100	100	100
1896	([b])	([b])	200	6	1,233	6
1897	100	100	500	41	833	39
1898	128	333	1,150	111	2,366	149
1899	186	25	1,600	25	3,223	27
1900	148	....	2,800	17	2,100	18
1901	31	....	650	9	866	9
1902	31	50	4,100	22	3,600	33
1903	571	483	8,550	42	1,393	123
1904	80	83	3,450	4	3,333	8
1905	600	367	7,650	38	12,100	49
1906	1,068	300	8,600	32	1,966	56
1907	691	733	6,800	44	13,200	95
1908	860	150	5,000	34	13,833	48
1909	354	100	5,250	34	8,900	55
1910	611	700	12,150	67	15,500	97
1911	460	350	12,600	132	13,966	142
1912	700	567	14,600	78	18,233	100
1913	611	517	93,500	23	14,100	59
1914	426	300	12,400	58	13,500	73
1915	263	317	20,250	40	18,300	57

[a] Including Pond-in-the-River but not Umbagog.

[b] There were no comparable records in 1895 and 1896. In 1896 there were 23 salmon and no trout recorded.

TABLE 7.—NUMBER OF SALMON AND TROUT OF RANGELEY LAKES AND RATIOS OF SAME TO THE FIRST OF SIX PERIODS OF FIVE YEARS EACH, OVERLAPPING TWO YEARS.

Period.	Salmon.		Trout.		Period.	Salmon.		Trout.	
	Number.	Ratio to 1895.	Number.	Ratio to 1895.		Number.	Ratio to 1895.	Number.	Ratio to 1895.
1895–1899	233	100	540	100	1904–1908	1,864	800	421	78
1898–1902	367	157	388	72	1907–1911	1,962	842	722	134
1901–1905	1,015	436	375	69	1910–1914	2,259	969	793	147

TABLE 8.—PERCENTILE PROPORTION OF SALMON AND TROUT OF RANGELEY LAKES AND RATIOS OF SAME TO THE FIRST OF SIX PERIODS OF FIVE YEARS EACH, OVERLAPPING TWO YEARS.

Period.	Salmon.		Trout.		Period.	Salmon.		Trout.	
	Percentile proportion.	Ratio.	Percentile proportion.	Ratio.		Percentile proportion.	Ratio.	Percentile proportion.	Ratio.
1895–1899	30	100	70	100	1904–1908	82	273	18	26
1898–1902	49	163	51	73	1907–1911	73	243	27	38
1901–1905	73	243	27	38	1910–1914	74	246	26	37

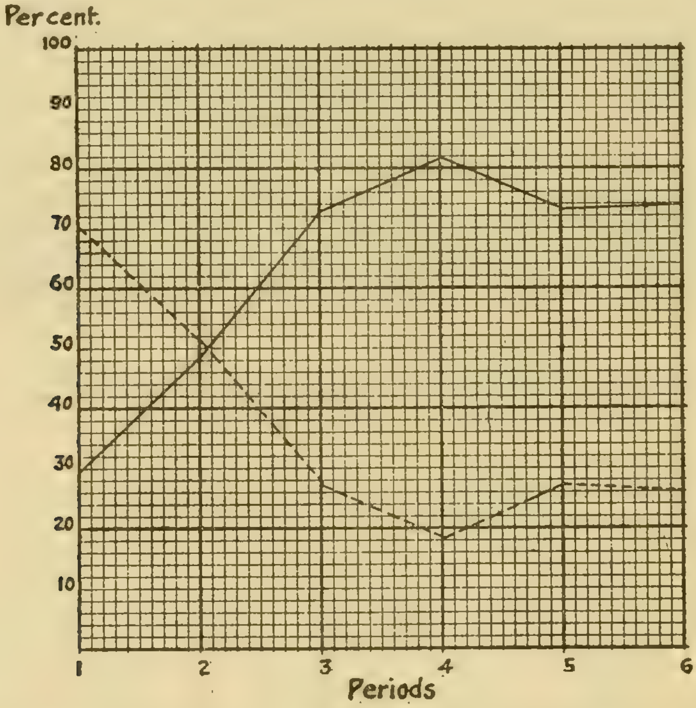

FIG. 16.—Percentile proportions of salmon and trout recorded from Rangeley Lakes in 5-year periods overlapping 2 years. Solid line, salmon; broken line, trout.

In these records the decline in the number of trout is markedly great in the first three periods, and this notwithstanding the increased number of fishermen. But in the last four periods there is a great increase in the number of salmon and an increase of trout in the last two periods. As is shown elsewhere, the increase in the catch of trout is due to an increased number of anglers and consequent records, with the admission of a greater number of the small fish to the records.

In 1903, according to Maine Woods, February 13 of that year, Capt. F. C. Barker, testifying before a legislative committee regarding the need of a fish hatchery at Rangeley, stated: "The salmon are increasing, while there is a falling off in the number of trout. Of course there are more people who fish for them than did a comparatively few years ago, yet the spawning beds show the decrease to a perceptible extent." Regarding the same matter, John A. Decker testified as follows: "The salmon fishing is good, while the trout are diminishing. While the salmon are a gamer fish, there is something attractive about the trout, and if the present conditions continue it will be only a short time before it will be a rarity to catch a trout in those waters."

The salmon preponderated over trout constantly in the records of catches in the Rangeley Lakes from 1899. Regarding the fishing in 1904 to August 13, Forest and Stream had the following communication:

> The fishing in Maine this season has been about up to the average. The trout, I think, have fallen off, but the salmon have more than made up the decrease in trout. They have thrived wonderfully, making their appearance in many new lakes year by year. If it were not for the landlocked salmon the fishing would have deteriorated very perceptibly. They are the coming fish in Maine.

Undoubtedly the increased output of the hatchery has had an appreciable effect upon the maintenance of the trout supply, as it has in the increase of the salmon. Yet the conclusion is unavoidable that the salmon have had a marked effect upon the trout supply of the lakes.

GAMENESS.—This salmon is undoubtedly one of the gamest of game fishes, but times and circumstances modify these qualities in one way or another. Trolling or plug fishing will not afford the sport that fly fishing does. As a rule, the smaller fish are far more active than the very large ones.

It is impossible to adequately describe all of the factors that enter into the composite characteristic termed "gameness," and it is unnecessary, as every angler who has caught the fish knows it well and those who have not caught them can form but little idea from graphic descriptions. Regarding gameness in proportion to the size of the fish, it may be said that as a rule the larger fish are less likely to do much leaping from the water, while small fish are very active leapers at almost any time of the year. About the middle of June the writer caught a 13-pound salmon, trolling a fly and using a 4½-ounce fly rod. The fish did not leave the water until netted and restricted his activities to short runs, sounding, and sulking. It took 40 minutes to get the fish. About the same date a 1½-pound salmon, caught on the same rig by casting in the outlet of the lake, although it required much less time to net it, leaped from the water 17 times by actual count, occasionally three or four times in rapid succession. It was stated in a sportsmen's paper that the 12½-pound salmon caught by Mr. Rogers in Rangeley Lake, September 25, 1898, was landed in 15 minutes, while one of 10½ pounds taken by Judge Whitehouse, June 9, came out of the water four times and was landed in 1 hour and 55 minutes.

It is the general impression that this salmon will not take a fly except in certain bodies of water, but there is probably no lake or stream inhabited by the fish where it will not take a fly in fly time, although the very large fish are less likely to do so than smaller ones. Such an impression probably got abroad through the fact that those who have tried the fly in doubtful waters have not long persisted in that method, their impatience causing them to soon resort to the customary method. However, it has long been demonstrated that the Rangeley Lake salmon is a fish that takes the fly, although formerly it was supposed not to. At Upper Dam in June, 1891, C. J. Bateman took a salmon on a fly, regarding which, Forest and Stream, June 11, of that year contained a notice to the effect that the fish weighed 7 pounds 14 ounces and was taken in the pool below Upper Dam on an 8½-ounce rod and Montreal fly. It was hooked at 7.45 a. m. and landed at 8.20 a. m. An elaborate account of the same event appeared in the same paper June 25, by which time the fish had apparently increased 10 ounces.

FISHING SEASON.—The fish usually can be caught by some means throughout the open season. This applies to any body of water inhabited by the salmon. The most productive time, however, is usually when the lake is free from ice up to the first of July or the beginning of the heated season. Occasionally one is caught by any of the usual methods during the summer, although stillfishing with live bait during July and August is the most likely method to yield fish. The largest salmon ever taken on a hook in Sebago Lake (22½ pounds) was caught in this way on a redfin bait, on the first day of August, 1907, but on the same day the writer caught a 16-pound fish by surface trolling, using a small smelt as bait. In some waters the fish has been caught by trolling and on a fly late in September, and the writer has caught the fish up to 3 pounds weight in early October in the Presumpscot River, the outlet of Sebago Lake.

FISHING PLACES FOR SALMON IN RANGELEY LAKES.—As in the case of the trout, in the early part of the season salmon may be taken almost anywhere in the lakes, but particularly about points and shoals and at mouths of streams, especially when smelt are running. Later in the season they resort to deeper water. Small salmon, and sometimes even large ones, linger in the quick water and pools below dams much longer than about the shores of lakes.

As has been stated previously, salmon seem to preponderate over trout in Oquossoc Lake, and it may be considered now a salmon lake. The salmon have made their way down the chain of lakes even into Umbagog Lake and the Androscoggin River, and occasionally some have been planted in the lower waters, as in Richardson Lake, Rapid River, and Umbagog Lake. It is quite noticeable, however, that the increase in numbers of salmon was gradually and successively progressive from the upper to the lower lakes. The first salmon in Umbagog Lake was mentioned in Forest and Stream July 24, 1884, which contained a statement to the effect that a 5-pound salmon had lately been taken there. In 1905 the salmon was reported to be common in that lake. A gill net set in the deep hole off Sturtevants Cove in 53 feet of water, August 17, took 6 small salmon measuring 14⅞, 15, 15½, 15½, 15⅞, and 16¾ inches, respectively. (See Table VII, p. 593.) A small one of perhaps 1-pound weight was caught July 17 in the Androscoggin River at the mouth of Molnichwock Brook. On August 23 a young one 7 inches long was caught on a baited hook at Molnichwock Falls.

In the spring and early summer excellent salmon fishing is said to be found at the foot of the rapids below Errol Dam and to some extent in pools on the rapids when the water is not too high or too low.

BLUEBACK TROUT (*Salvelinus oquassa*).

A group of chars comprised in the genus *Salvelinus* and composed of a number of nominal species completely encircles the Northern Hemisphere in its geographical range and is restricted at the north only by perpetual ice. Its southward extension varies as indicated by the recorded distribution of the nominal species but is essentially boreal or alpine, occurring in the eastern United States in only a few isolated instances. At the time the blueback was first scientifically described [a] no other species of char, excepting the common brook trout, was scientifically recognized in the eastern United States, and since then only comparatively few specimens have found their way into collections, and very little has been written about this species. Therefore, there is a dearth of information regarding its relationships and habits, and most of that which is known is scattered through sportsmen's journals. Forty years after Girard called the attention of the Boston Society of Natural History to this fish Dr. David S. Jordan [b] stated that no specimens were on record from any waters in the United States other than the Rangeley Lakes. Dr. Jordan seemed to consider it specifically identical with an Arctic char described under the name of *Salmo narcsi* by Dr. Günther [c] and also with specimens collected by Kumlien at Cumberland Gulf and identified by Dr. Bean as *S. narcsi.* Dr. Jordan expressed the opinion that it was probably an Arctic fish that for some reason kept its hold in the Rangeley chain but had become extinct in other lakes of northern Maine, if it ever lived there.

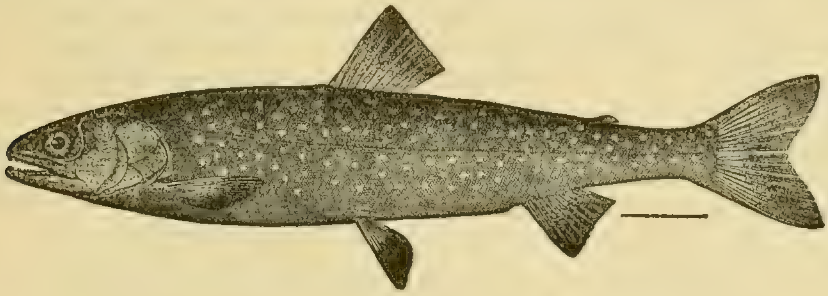
FIG. 17.—Blueback trout (*Salvelinus oquassa*).

Later, however, Dr. Bean [d] wrote that the blueback was certainly known only from lakes and streams of western Maine, but thought that the justice of its identification with Nares trout was open to question. In American Fishes (1888) G. Brown Goode said that the blueback was probably a landlocked form of *S. stagnalis*.

The blueback is undoubtedly not only closely related to the previously mentioned fish but to other nominal species of Arctic chars, as well as to the European saibling and the later described Canadian red trout and golden trout of Sunapee Lake and other New England waters. In fact, it has been suggested that all are specifically identical but subject to ontogenetic variations.

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[a] Charles Girard, at the meeting of the Boston Society of Natural History of Oct. 20, 1852. Proceedings, Boston Society of Natural History, vol. 4, 1853, p. 262.

[b] Forest and Stream, Dec. 14, 1882, p. 389.

[c] Proceedings, Zoological Society of London, 1877, p. 476.

[d] Forest and Stream, supplement, Apr. 4, 1889.

Unless the blueback is identical with those other forms, its known range was, until 1905, restricted to the Rangeley Lakes. In that year, however, the writer[a] provisionally recorded as this species specimens from Rainbow Lake, the headwaters of a tributary of the West Branch of Penobscot River, Piscataquis County, and later additional specimens were received from the same place. Very possibly careful search might reveal them in other Maine waters.

SIZE.—Girard stated (loc. cit.) that the fish attained from 8 to 10 inches in length. The Report of the Maine Fish Commission for 1874 stated that it was reported to reach a length of 8 inches, and the report for 1878 said that the fish were quite small, usually averaging four or five to the pound. H. O. Stanley, one of the Maine fish commissioners, wrote in a letter to Fred Mather[b] that he did not believe that out of a thousand two could be selected that would vary 1 ounce in weight, or that five could be picked out that would vary an ounce from a pound, aggregate weight.

In 1883 Mr. Rich stated (loc. cit.) that he had never seen one that weighed over 6 ounces, and in another place he said that they ran from 5 to 8 inches in length and weighed from 4 to 6 ounces. In American Fishes, previously cited, Dr. Bean was quoted to the effect that it was not known to exceed 10 inches in length from existing collections, but that specimens of much larger size might be expected. In the revised edition of the same work in 1903, edited by Dr. Theodore Gill, it was stated that anglers now and then catch what seemed to be bluebacks weighing as high as 2 and 2½ pounds.

HABITS.—While the first published information respecting the blueback was that by Girard (loc. cit.), it was locally known, particularly to the inhabitants of the region and to a few visitors, many years prior to Girard's notice. In an article entitled "Blueback trout,"[c] J. G. Rich, a resident of Bethel, Me., wrote that in 1844 he visited the Rangeley Lakes and then first heard of this fish, which the settlers called blueback, not apparently regarding it as a trout. At that time, he stated all that was known regarding the fish was that about the 10th or 20th of October of each year they ran up what was called Toothaker Cove from Rangeley Lake into a small brook, the outlet of Quimby Pond.

Girard stated that the abode of the blueback was "Moosemegantic" Lake, in which, he said, it remained concealed during the greater part of the year, and indicated that about the 10th of October it came near shore and ascended in shoals the Rangeley outlet to "Lake Oquassa." After the middle of November, he mentioned, the fish returned to Mooselucmaguntic Lake and was seen no more until October of the following year. However, Mr. Rich wrote (loc. cit.) that until the building of Upper Dam about 1858, when the fish was discovered in Kennebago and Rangeley Streams and below Upper Dam, he had never seen it in any other stream than the outlet of Quimby Pond, which in a later article he designated as Dodge Pond outlet. This stream, however, is the joint outlet of both ponds. He stated that although he had fished all of the Rangeley Lakes, the Magalloway, Parmacheenee, Cupsuptic, "Beama", Kennebago, and Rapid River waters for more than 35 years he had never seen the fish elsewhere than in the places first mentioned and at no other season of the year than the late fall months. But later he was informed that they had appeared below Middle Dam.

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[a] Maine Sportsman, Feb., 1905, p. 117.

[b] Forest and Stream, May 5, 1887.

[c] Forest and Stream, Jan. 4, 1883.

Another correspondent[a] of the same paper wrote that the bluebacks had not that year appeared in wonted numbers at the Upper Dam, but that they had been observed in large numbers at the mouth and well up in Sawmill Brook, a narrow rocky stream.

Regarding the run of bluebacks in Sawmill Brook in the fall of 1887, Oscar Cutting, a guide of the region, was referred to in Forest and Stream, December, 1887, as reporting that the stream was lined with them for some distance up the brook and that so intent were they upon reaching their breeding grounds that the fish were piled up in the shallow water in the little pools and eddies.

Capt. F. C. Barker (loc. cit.), writing regarding their disappearance from below Upper Dam and appearance in Sawmill Brook, said that the disappearance was plainly due to the fact that the water in the lake below was so high that it backed up over the rips where they usually spawned, "rendering the whole line of rips as quiet as a mill-pond." Capt. Barker expressed the view, also, that the large numbers occurring that year in Sawmill Brook were attributable to this cause, but he thought more or less of them had always spawned there.

The previously mentioned characteristics were also referred to in the reports for 1875 and 1878. In American Angler, April 14, 1873, Mr. Rich wrote that they ran up the brook at night and back in the morning. Forest and Stream, November 26, 1874, said that on the 10th of October, or within three days of that date, the outlets of Gull and Dodge Ponds, both emptying into Rangeley Lake at points 6 miles apart, and the outlet of Rangeley Lake, 6 miles from Dodge Pond, were thronged by myriads of these exquisite little fish. The waters of the streams were said to be actually filled with a crowding, springing multitude, gathering like smelts and alewives to deposit their spawn. It was stated that they did not make spawning bed as did salmon and trout, but deposited their eggs in all parts of the stream, remaining about 10 days, when they returned to the lake, to be seen no more until the 10th of October the following year.

In the same paper for December, 1874, Elmer Merrill wrote that five or six years previously he had spent the month of October in this region and for the first time saw the blueback trout of which he had heard. He said that the fish came up Rangeley Stream from Cupsuptic and Mooselucmaguntic Lakes to the pool below the dam, where they were observed in myriads, the water being literally black with them, and from under every stone, slab, or log in the stream scores would shoot out when disturbed. He said also that the same conditions obtained in the streams emptying into Rangeley Lake.

In a letter to Fred Mather, published in Forest and Stream, May 5, 1887, Commissioner Stanley wrote that the bluebacks were very hardy fish and nearly as tenacious of life as the eel or bullhead. He stated that he had frequently seen them alive in the morning after they had lain on the shore all night.

Regarding the same matter, J. Parker Whitney[b] wrote that they were much more tenacious of life than the brook trout and that he had had them out of water an hour, apparently lifeless, and resuscitated them by putting them in water again. He said that a number would live in a barrel of water without change for weeks, which treatment would be fatal to the ordinary trout.

FOOD.—The only mention of the food of the blueback is the statement of J. Parker Whitney (loc. cit.), who said that their teeth were very fine and numerous and that they evidently lived upon "ground feed and the variety of infusoria which are so plentiful in the lakes." Mr. Whitney, in a letter to the same paper in 1900, explained that "ground feed" of the lakes was "an important element with all fish, composed of insectivorous varieties and largely of viscous matter which settles profusely."

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[a] Forest and Stream, Dec. 15, 1887, p. 408.

[b] Forest and Stream, Oct., 1896, and Report of Inland Fish and Game Commission of Maine for the year 1896.

The stomach contents of some small bluebacks of Rainbow Lake consisted of a large quantity of insect larvæ and entomostracans. These fish were taken in the latter part of the winter by bait fishing through the ice.

CAPTURE.—George Shepard Page, in 1874 (loc. cit.), wrote that notwithstanding the great numbers of anglers who have frequented the Rangeleys during recent years, fishing all portions of the lakes with all manner of bait on the surface and down in the deep, no one had ever caught a blueback and none had ever been seen at the surface.

E. S. Merrill (loc. cit.), stated that his party did take a few with bait in Rangeley Stream.

The Maine commissioners' report for 1874 said that now and then in deep fishing with bait in the lakes one was caught and that exceptionally in the breeding season one would take a bait, but it was not considered a "biting or game fish," although he had caught a bushel and a half in a day with baited hook. They were caught mostly with dip nets.

However, the report for 1878 stated that the fish haunted the deep water in ponds, where they could be freely taken in summer with baited hook in about 40 feet of water.

Capt. Barker (loc. cit.) said that sometimes a blueback would take a bait in deep water, but never knew of one taking the fly.

The usual method of capture was, as stated by Mr. Stanley, by means of dip nets while the fish were ascending the brooks in October.

Mr. Rich[a] said that in 1844 they were taken in large quantities by the Rangeley people, though they never fished for them with a baited hook, but either netted or speared them. Mr. Rich said that he had been informed that the fish could sometimes be taken with a baited hook, but that he never succeeded in catching one or even attracting their attention. He described the method of fishing[b] in words to the effect that improvised nets consisting of bags with ash bows and handles were set in sluices or fishways constructed of rocks in such a way that the fish were guided into the nets. In this way, he said, several bushels would be secured by each man in a night, which was the only time they could be caught, as they ran up at night and back before morning.

The various communications are somewhat contradictory regarding the presence of fish in the brooks during the day. It is probable, however, that while some may have returned to the lake during the same night many did remain for a longer time, but being for the most part concealed, as one person stated, the impression was given that the brook was vacated. Those who caught the fish with baited hook in the brooks at this season undoubtedly took them in the daytime.

Regarding the capture of some by hook in the spawning season, it may be said that this is not improbable. However, those caught by this means were probably fish that had finished spawning and had lingered in the stream, as is the habit of a number of salmonoid fishes, especially the males, and which have been known at such times to take a baited hook which they would not notice prior to spawning.

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[a] Forest and Stream, Jan. 4, 1883.

[b] Forest and Stream, Jan. 4 and Apr. 4, 1883.

Forest and Stream, August 6, 1898, contained a communication from a Rangeley Lakes correspondent, in which it was stated that a blueback was reported to have been taken by trolling.

FOOD VALUE.—Referring to a special exemption of the blueback from protection by the law applying to other trout, a correspondent of Forest and Stream, November 26, 1874, expressed the opinion that it was proper and wise, as it enabled the settlers in that section to supply themselves with quantities of superior fish food that, smoked and salted, added very materially to their limited bill of fare.

Forest and Stream, November 15, 1877, indicated in the following statement that this fish was to some extent marketed: "The first of the Rangeley bluebacks have come to the market from Maine and will be as usual at E. G. Blackford's stall in Fulton Market."

According to Mr. Rich, the settlers prepared those caught on the spawning beds in the fall for their use as food in the following winter and summer. Some were cured by salting, others by drying, and still others by smoking. Some dressed them, others cured them whole. Mr. Rich wrote: "It is proverbial of certain families that they lived on bluebacks and crossbills," and that the crossbill, a small bird, was cured whole.

Regarding its gustable qualities, opinions seem to have differed, as indicated by those expressed by the various individuals previously referred to in this paper. However, the pro and con opinions may each have been based upon different conditions. The first run of fish prior to spawning would be in much better shape than some time after spawning and before they had recuperated. This may be said respecting any fish.

Girard pronounced the blueback highly flavored and more delicate than the brook trouts in Europe and America and said it resembled *S. umbla* of the Swiss lakes in peculiarity, habits, and delicacy.

Mr. Merrill found them a nice pan fish, "juicy, tender, and delicate," but he preferred the brook trout.

The Maine fish commissioners, in their report for 1874, stated that they had eaten only fish taken on the spawning beds and to them it was not palatable but was as much so as the brook trout under the same circumtances. On the other hand, in the report for 1875, the statement is made that it was an excellent table fish, "most persons deeming it equal in flavor to the brook trout," and, again, the report for 1878 said that it was much esteemed as a fine pan fish.

A correspondent of Forest and Stream, December 15, 1887, wrote that although males were selected the flavor was not generally pleasing. Mr. Whitney (Forest and Stream, Nov. 24, 1900) said that for food purposes it was inferior to the brook trout and to his taste it was soft and muddy.

EARLY DESCRIPTIONS.—Girard (loc. cit.) described the blueback as follows:

> It is from 8 to 10 inches in total length. The body is subfusiform, slender, and the most graceful of the trout family. The head is proportionately small, conical, coregonoid in shape. The mouth is smaller than in *S. fontinalis*. Differences are likewise observed in the structure of the opercular apparatus. The fins have the same relative positions as in the brook trout but are proportionately more developed, with the exception of the adipose, which is considerably smaller; their shape is alike, except that of the caudal, the crescentic margin of which is undulated instead of being rectilinear. The scales are somewhat larger, although they present the same general appearance as those of the brook trout. The lateral line is similar in both of these species. A bluish tint extends all along the back from the head to the tail, so that when seen from above the fish appears entirely blue; hence, the name "blueback" given to

> it by the settlers of that neighborhood. The sides and abdomen are silvery white in the female and of a deep reddish orange in the male, spotted in both sexes with orange of the same hue as the abdomen. The dorsal and caudal fins are brownish blue bordered with pale orange in the male; the pectorals, ventrals, and anal of a fiery orange, blackish blue at the base, with their margin of purest white. When first taken out of the water, it is impossible to imagine anything more beautiful and more delicate in the way of coloration in fishes of the temperate zone.

Mr. Page said of them (loc. cit.) that they had no bright vermilion spots; the ventral, anal, and pectoral fins bright scarlet, but without the black and white lines so conspicuous on the brook trout; and the tail more forked.

In Forest and Stream, December 10, 1874, page 277, C. A. Kingsbury, of Philadelphia, stated that he had received some bluebacks, a careful, critical examination of which led him to believe them to be an undescribed species, and at the meeting of the Philadelphia Academy of Sciences, November 17, 1874, he had presented the specimens and given a minute description of the species under the name of *Salmo cœruleidorsus*. This communication was referred to the standing committee on ichthyology, and at the suggestion of Dr. Leidy a specimen was sent to Prof. Baird, who advised him that it was the *Salmo oquassa* of Girard. In the same paper, on the same page, was published a description of the fish by James W. Milner, under date of November 29, 1874, to whom it appears Mr. Blackford had sent specimens. He stated that the form of *oquassa* was much more slender and with a tendency to prolongation not seen in the brook trout. Thus, in the depth of body and of head compared with their lengths, the pectoral fin prolonged to a slender point, the two lobes of the caudal extended in the same way, showing a decided furcation, and the opercular bones prolonged into a more acute angle. On the contrary, the maxillary bone did not extend as far back of the eye, in *S. oquassa* trout. The interopercular bone is much larger in *S. oquassa* and the suboperculum is wider. The tail in *Salmo fontinalis* is more truncated than in any species it is likely to be confounded with. The following is taken from the Maine commissioners' report for 1874, pages 17 to 18:

> This beautiful little fish takes its name from a bluish tint on the back, not unlike the bloom of a plum. They are spotted like a trout, and to a casual observer the difference in a basket of fishes would not be noted. But like the togue they have only the yellow and black spots but not the red. Their tints and colorings are very beautiful, particularly in the male, the pectoral fins rivaling in color the autumn-tinted maple leaves. Like the dying dolphin, their brilliancy of color is lost or fades away with their lives. They are more delicate and symmetrical in shape than the brook trout and have the tail forked.

In his letter to Fred Mather in 1887 (loc. cit.) Mr. Stanley wrote:

> The adult fish does not have any white on the fins at all like the brook trout. The fins of the male are bright red or the color of bright autumn leaves. When taken from the water they are of a dark color, but after death turn to a light yellowish cast. The spots are very minute, very thick, very bright yellow and red; both thicker and brighter than on the brook trout.

PROTECTION.—It has already been mentioned that under the general trout law the blueback was afforded no protection. The first protective law for trout seems to have been enacted in 1869, chapter 20, section 18, in which the blueback trout in Franklin and Oxford Counties was specifically exempted.

The great abundance of this fish having been maintained for so many years in the face of the great slaughter on the spawning beds and the importance of the fish in the winter food supply of the settlers indicated that protection was not needed or desirable. However, as early as 1874 the Maine fish commissioners' report for that year stated that it was the opinion of the commissioners that it was a great mistake to allow these beautiful fishes to be taken at all, as it was to the blueback that they attributed the great size of the Rangeley trout. They further stated that it was their opinion as the blueback diminished in numbers so would the far-famed Mooselucmaguntic trout, and went on to say that the blueback was to the Rangeley Lakes what the myriads of smelt were to Sebago Lake and Reeds Pond.

Capt. Barker[a] wrote that the fish was very valuable as food for the brook trout and stated that it was a very common occurrence to catch trout in deep water with a blueback in its stomach, especially in the winter.

Finally, some time in the nineties a comparatively rapid decrease in the number of bluebacks appearing in their accustomed spawning places became so marked that protective legislation was urged, but it was not until 1899 that a law was passed providing that "it be unlawful to fish for, take, catch, or kill any blueback in any waters of the State at any time" (chap. 42, sec. 5, P. L. 1899). Protection, however, had been too long delayed.

In the fall of 1900 the writer visited Oquossoc Lake with a letter from Commissioner Stanley to George Esty, a reliable fish and game warden of that region. Mr. Esty's aid in every way possible was requested in the letter. A man in whom Mr. Esty had confidence agreed to watch a certain stream where the fish used to fairly swarm and, as Mr. Esty said, were dipped and hauled away by the barrel and cartload. This man watched the stream throughout the spawning season without seeing a single blueback. This was the famous outlet of Dodge and Quimby Ponds. In Kennebago Stream, the Oquossoc Angling Association caught one pair of bluebacks. The male had been liberated but the writer secured the female, which weighed about 1 pound. In 1902 a few large bluebacks were taken by spawn takers, and in 1903 five more, all that were taken, were secured by the writer. In 1904 another visit was made by the writer to Oquossoc Lake. The State fish hatchery located on Rangeley Stream was then in operation, and the fish culturists were taking trout and salmon in that stream by means of a weir and in Kennebago Stream by seine. Only three bluebacks, these ranging as high as 2 or 2½ pounds, were secured or observed, although they were looked for at all of their former breeding places. The writer has been unable to learn that even a single specimen has been taken since. It would seem, therefore, that the blueback is probably extinct in the Rangeley Lakes. In the Maine Sportsman, February, 1905, referring to the probable cause of the decrease in numbers of bluebacks, the author wrote:

> There is evidently a recent decrease in the numbers of this fish, almost to a complete disappearance from their usual spawning grounds. On the other hand, occasionally fish larger than used to be caught, even up to 2 or 2½ pounds, I am told, are caught by anglers, when fishing for other trout and the salmon, both in Mooselucmaguntic and Oquossoc Lakes. That these fish are verging on extinction in these waters can not, I think, be wholly ascribed to excessive fishing. For much more than 50 years such fishing has been carried on with but little appreciable diminution of their numbers. Of course, injurious effects are sooner or later inevitable from such drafts upon them. But in their case it seems as if there must be additional factors at work. Here again our conditions of growth and existence may be brought into consideration. If trout depended largely upon bluebacks for subsistence, salmon rapidly increasing in numbers in these waters would doubtless come in for their share. Recognizing this possibility, the State commission planted smelts in the lakes in 1891.[b] They have also flourished and waxed great in numbers.

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[a] Forest and Stream, Jan. 12, 1888.

[b] In 1900 a spawn taker of the Rangeley and Oquossoc Angling Association told the writer that 1891 was the date of the first plant of smelt in these lakes.

The decrease in numbers of bluebacks was synchronous with the increase in number of salmon, and coincidently the last blueback was taken in the year following the largest catch of salmon up to that date. There can be no doubt that the blueback entered largely into the food of the salmon, especially prior to the introduction of the smelt, living as it did in the deep waters to which salmon resorted during the summer months, and the introduction of smelt and later legislative action were both too late to save it. On the other hand, the large size of the few surviving bluebacks was very probably due to the smelt. Although the food of the blueback was formerly the smaller animal life of the lake, probably largely consisting of entomostracans, insect larvæ, and worms, the smelt afforded it an abundant additional supply of food, owing to the fact that while almost in a larval stage young smelts frequent deep water after leaving their birthplaces in the brooks. (See Tables VII, VIII, p. 593.)

WHITE TROUT (*Salvelinus aureolus*).

To the fish culturists this char is known as the golden trout or aureolus and sometimes as Sunapee trout or Sunapee Lake trout, these latter names due to its having been first discovered in Sunapee Lake, N. H. The name golden trout is derived from its technical name, *aureolus*, which was given to it in reference to the golden sheen of the living fish in the water. The local name, white trout, is more appropriate to its summer coloration, when the brilliant orange of the males is absent. It is known as white trout at Sunapee Lake and is thus distinguished from the common trout (*Salvelinus fontinalis*) which at Sunapee Lake is called native trout, due to the popular impression, doubtless, that the white trout was introduced.

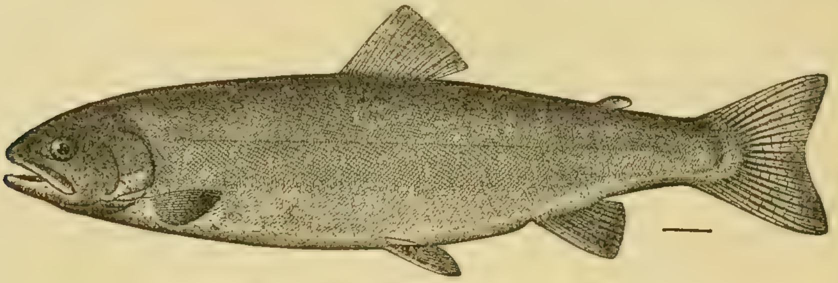

FIG. 18.—White trout (*Salvelinus aureolus*).

About the time the fish was discovered at Sunapee Lake there was an animated discussion regarding its identity, some claiming that it was the result of introduction of the saibling (*Salvelinus alpinus*) from Europe. But it was pretty conclusively shown that none of the lot brought from Europe was placed in Sunapee Lake or into any waters from which it could gain access to that lake. Others claimed, with more basis for their claim, that it was a blueback which there is no doubt was introduced about five years before the so-called discovery of this fish, which had attained a large size owing to favorable conditions in the lake. Some individuals were not wanting who averred that they had known the fish for many years prior to the introduction of bluebacks. The blueback advocates would have rejoiced had they foreseen that this fish in its native waters would reach the size of an average Sunapee white trout, as the main argument against the blueback theory was the small size attained by the blueback. As a matter of fact, the small size was the chief difference. Dr. Bean mentioned one additional character; that is, the difference in the gill rakers, which in the blueback were always straight and in the Sunapee fish usually more or less curled and distorted. But this character does not obtain in the small Sunapee fish, and in the large blueback they are frequently as distorted as in the Sunapee fish. Indeed, it is a difficult matter to distinguish a large blueback from a white trout after it has been preserved in alcohol for some time, or even when fresh. The writer, some years ago, suggested that the differences were ontogenetic. Such differences as exist as shown by the specimens examined are shown in the description of the blueback.

The white trout has been found also in Dan Hole Pond, N. H., Floods Pond, Me., and Averill Pond, Vt. Its discovery in these ponds precludes the necessity of going to Europe to account for its presence in Sunapee Lake. It seems unaccountable to many that the fish could have existed always in Sunapee, fished so much as it was, and not be detected before. As a matter of fact, this is not an unknown phenomenon. While the ponds subsequently found to contain white trout were perhaps not fished quite as generally as Sunapee, yet they were probably fished as much by the inhabitants about its shores, who, doubtless, did not distinguish the fish from the common trout, at least only to the extent of considering it a peculiar form of the latter.

The white trout is a rich and savory fish for the table, being fat in season, to which its flavor is apparently due. It is caught mainly by plug fishing with live bait and cut bait and very occasionally with worms. Not infrequently it is taken by trolling, but with a deep line as a rule. The best bait seems to be the smelt, which was introduced into Sunapee Lake and has always existed in Floods Pond. It is sought by still or plug fishing in about 80 or 90 feet of water in Sunapee Lake and about 30 to 40 feet in Floods Pond (in June). The fact that it is a deep-water species would in part account for its being seldom observed by the old inhabitants.

It is said to attain a weight of 10 pounds in Sunapee Lake, but a fish of 5 or 6 pounds in recent years is a monster.

In 1903[a] or 1904 white trout were planted in Mooselucmaguntic Lake, according to the report of the United States Bureau of Fisheries for that year. It is not known with what results; and probably should one or more be caught it would be considered another big blueback, to go on record as that species caught on a hook, which is a rare occurrence. It is unfortunate that the fish was planted in these waters, for it will confuse the history of the blueback, which, if not quite extinct, might increase in numbers again, and new reports of bluebacks will not be positive.

BROOK TROUT (*Salvelinus fontinalis*).

This char is everywhere in Maine the trout or brook trout par excellence. It is naturally peculiar to eastern North America. In Canada it occurs in many streams and tributary waters of the Great Lakes and St. Lawrence River and the Gulf of St. Lawrence as far north at least as Hamilton Inlet on the Labrador coast. Its northern limit is not definitely known, but it is restricted on the east by the Atlantic Ocean and it extends southward in the Alleghenies to headwaters of streams in the mountains of Georgia and Alabama.

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[a] There is an element of doubt attached to this record. The late State Commissioner Brackett wrote in reply to an inquiry regarding it, made about the time the record was first published, that he had no knowledge of any such plant. It is possible that it was an error in copying localities when the report was prepared.

This trout is, or was once, everywhere common in Maine, and the Rangeley Lakes were not the least renowned for this superb fish. It is closely related to the blueback and other chars of which mention has been made but having quite distinct coloration, and it is generally less slender in form than the others. Among themselves, however, the trout differ greatly in shape and color, not only those from different waters but often those of the same body of water or different localities in the same lake or stream. Modifications of both form and color appear in the breeding season. In the Rangeley Lakes region differences of form as well as of color have been noted, giving rise to the suspicion that they might be distinct species, if not actually regarded as such.

J. G. Rich, of Bethel, Me., to whom reference has already been made, a man of many years' acquaintance with the trout of Rangley Lake, contributed an article entitled "The trout of Maine waters" to the American Angler, April 14, 1883. Mr. Rich was inclined to believe that more than one species of trout, besides the blueback, existed in the Rangeley Lakes. In the way of illustration he described several contrastive forms. One locally called the cedar tree trout, receiving its name from Cedar Tree Point, near which it spawned, was thought to differ more pronouncedly from the other trout than the landlocked salmon did from the Penobscot salmon. However, he stated that he sent one to Prof. Agassiz, who pronounced it "nothing else than simon pure *Salmo fontinalis.*"

The cedar tree trout was stated to be thin, flat, and short, with very highly colored sides. Contrasted with it was a long, round, light-colored, almost silvery trout, with white flesh, occurring in deep waters. Another of similar appearance, weighing about three-fourths of a pound and having yellow flesh, was said to congregate at the mouths of certain brooks during the last of August and first of September. Still another, but very plump and with red flesh, occurred at some other places. In the spawning season, October and November, even as far up as the small headwaters of "Beama" Stream, Metallak Brook, and the inlet of Richardson Ponds, there was said to be still another highly colored variety, which ran in weight from about 3 ounces to a pound and in appearance was the most beautiful of all, but no better, if as good, for the table. Among these, he said, were found both red and white meated fish. He went on to say that in many years of winter fishing very few of this kind of trout were caught in the lakes and ponds and were seldom taken except on the spawning grounds. He concluded, therefore, that they did not mix with the other kinds but probably resorted to some special location.

Continued residence of trout in one locality modifies the appearance of the fish according to the conditions obtaining in the locality. The appearance of trout as affected by various environments and conditions may be stated in general somewhat as follows:

Slender, light-colored, silvery trout in clear, sandy lakes and ponds, or localities in bodies of water where such conditions obtain, and clear, sandy, quick-water streams.

Stout, dark-colored trout in lakes or ponds or localities of lakes or ponds having muddy bottom and considerable vegetable growth, and particularly water discolored by vegetable stain. The same may be said of streams, and it may be added that the swifter the flow of water where the trout occurs the slenderer it is likely to be. Various degrees and mixtures of conditions correspondingly modify the fish subjected to them. The shape and color also vary with the size and age of the fish and, as previously stated, are often greatly changed in the breeding season.

Most of the distinctive colors and form characters of Mr. Rich's cedar tree trout and of the upper-water brook trout were obviously the color modifications which take place in the breeding season, which is accounted for by their seldom being caught at any other time. Occasionally, after the breeding season recuperation is delayed and the trout retains the appearance of the breeding fish for an unusual period.

Mr. Rich referred to the color of the flesh of the trout as though it were a variety characteristic. The cause of this red color has long been a mooted question. A theory that has been entertained for many years is that it was attributable to red-pigmented food, such as some crustaceans. This theory seems to be defective, for other fish feeding extensively upon exactly the same kind of food always have white flesh. Young or rapidly growing trout never have red flesh, but under uniform favorable conditions a change from white through various shades of yellow, pink, and red may be traced, the intensity increasing as the fish approaches maturity. Breeding fish often rapidly lose the red or yellow tint, becoming white meated. Apparently, trout of some waters are always white meated and others, while attaining a yellow shade, never reach the red stage. These last two phases are particularly noticeable in fish which pass much of their life in quick water.

After taking everything into consideration, it would seem that the character or quantity of food influences the color of the flesh only in its fattening effects, and it is only the intrinsic fat or oil in the fish which produces the red flesh and delicious flavor of the red-meated trout. The oil or fat is naturally red as that of some other animals is naturally white or some other color, and it is the amount permeating the fish that gives the color its intensity. A well-fed, comparatively inactive adult trout will present a more intensive shade of the flesh than a fish of the same age living in running water, where its livelihood depends upon its activity, although it may be a well-conditioned, shapely fish. In the latter instance the food has been assimilated and utilized in the development of energy. The fact that, according to Mr. Rich, both red and white meated fish are found in the same school on the spawning beds does not detract from the theory, for probably all individuals are not equally fat or equally advanced in the spawning process, and the meat of such fish inversely and progressively, or sometimes irregularly, becomes white. Besides, as Mr. Rich in another place stated in effect and as has been observed, there are almost always immature males on the ground for other than breeding purposes, which seems to be to augment their diet at the expense of the breeding fish; that is, by eating the eggs as deposited.

FOOD.—The trout seems to avail itself of whatever animal life is available, and vegetable food is not always eschewed. A detailed list of what trout have been known to eat would be more astonishing than valuable. However, the general and principal food supply upon which the adult fish depends may be divided into two classes—fishes and insects.

The trout of brooks subsist largely upon insects, particularly the aquatic larvæ of numerous species, such as caddis flies, May flies, *Chironomus*, and dragon flies, and also upon insects that fall upon the water or hover over the water while depositing their eggs. The food of trout of larger streams, ponds, and lakes, of course, consists of the particular kinds that the waters afford and these often differ materially from each other and seasonably in the same water. In all waters there is a seasonal supply of insects that varies with the season and locality, but where food in the form of fishes is available the insect food appears to be more or less neglected, particularly by the larger fish.

The diet of the trout, however, varies not only with the season but with the age of the fish. The seasonal variation, however, may be one of convenience, but that of different stages of growth is influenced by suitability.

The first food of trout fry consists largely of minute crustaceans and small insect larvæ, such as *Chironomus*, black fly, etc.; and that of the fingerling, of larger insect larvæ, worms, and small insects, which diet, however, is not exclusive and is controlled more or less by the habitat and environment.

The regular food supply of the adult trout of Rangeley Lakes, aside from the insects and more or less accidental or incidental animals, was formerly, without much doubt, the small fishes occurring there, including its own young and eggs to some extent. The blueback trout was believed by the late Commissioner Stanley to have been the main dependence of the large trout and that it was due to the blueback that the trout attained its large size.

J. Parker Whitney,[a] to whom reference has previously been made, said that in December and January there was a notable scarcity of live bait, meaning small fishes, and that in February and March it was very difficult to find. "Yet," he said, "the trout are seldom empty of small fry or chubs, and it is quite likely that the trout root them out of the mud. This is indicated by earth and often lumps of clay found in their stomachs." He stated that he had caught large trout often with a small handful of clay balls in their stomachs. "In winter," he continued, "the contents of their stomachs are quite miscellaneous—glutinous ground feed, chubs, varieties of small fry, rarely bluebacks, suckers, and in a few instances I have found whole clams in shells up to 3 inches in length."

If the disappearance of the blueback deprived the Rangeley trout of an important food supply, it has been more than compensated for in the smelt which was introduced. In the Rangeley Lakes the smelt does not attain a large size, has multiplied tremendously, and is locally available as food for trout from one end of the year to the other.

Regarding the smelt, Mr. Whitney wrote (loc. cit.) that it was apparently an admirable food for the salmon and trout and in the spring seemed to be their principal food, as their stomachs seemed to be crowded with them, and that he had repeatedly observed from 50 to 70 in the stomach of a single large trout.

FEEDING TIME.—The feeding habits of trout are influenced by both internal physiological and external physical conditions, so that it does not feed at all times of the year or the day. While it takes food readily up to the breeding time, breeding fish are not much inclined to feed. The postnuptial wasted condition of the fish would naturally impel it to recuperate by feeding, but at that time food is scarce. This, however, is compensated for by the cold water making the fish more or less sluggish or dormant, when there is little metabolism and little or no food required. But these two forces are contending, as it were, and the fish, therefore, will eat when there is anything to eat, but they can get along without it. The warming of the water and other physical changes stimulate them to activity and need of food. The foregoing statement, however, should not be construed to mean that trout do not feed in the winter time when food is available, for it is well known that they are readily taken by fishing through the ice, but in this case the best fishing is in the latter part of the winter. Therefore, it would seem that to some extent its abstinence, if any, is enforced partly by scarcity of food.

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[a] Forest and Stream, Nov. 24, 1900.

There seem to be instances, judging by the behavior of the fish toward anglers, when the fish do not feed much during the summer months, especially at the surface in warm bodies of water, and such feeding as there is occurs during the night or on overcast or rainy days. Moreover, during the recognized fishing season there are often days when the fish will not take bait or fly, and during the day when feeding the time is usually early in the morning or in the cool of the evening.

It is a matter of common remark that on some days trout will bite ravenously and on the following day or for days it will not bite at all; also, at times the fish will rise to a fly freely for some time and then suddenly cease to rise, although there are many fish still there. Pertinent to this subject at the Rangeley Lakes, an angler wrote regarding September fishing that for 10 successive days he cast steadily, "whipping every nook and corner" of the pool at Upper Dam, without a single rise, yet he could see the big fellows breaking water every little while. He said that on September 15 he fished Cedar Tree, Minters Favorite, and Metallak Brook without getting a rise. Then he tried Brandy Point, Sandy Cove, and Trout Cove with the same result. "The fish were there—I saw dozens break water—but they would not bite."

In contrast to the foregoing experience was that of another angler, who, speaking of the pool below the old stone dam at Upper Dam, said that it was a cold, blustering gusty day, with occasional sleet, late in September, so cold that he frequently had to go ashore to a fire to warm his benumbed hands. He stated that he caught on a fly in rapid succession 10 fish, ranging from 3 to 8¾ pounds and aggregating 57 pounds.

Referring to the celebrated Marble-Morse fish mentioned in another place in this report, an angler present at the time of its capture wrote that he remembered how for several years in the autumn the great trout came alone to the same place in a moderate swirl of water above the dam. He said that the fish became the target of many ambitious efforts of both fly casters and bait dabblers. On occasions he would signify his presence by rising to the surface, and with a quiet surface and the sun's rays in a favorable quarter he could be observed lying quietly or slowly moving about. Flies were cast and sunk, also worms, grasshoppers were lowered and trolled in vain, until one day an old guide "who would have scorned to have taken him any other way than fairly, allowed his worm-baited hook to rest upon the bottom for a while, from which it was seized by the fish, which soon lay gasping on the grass."

It is evident that the apparent caprices or idiosyncracies of trout are too much individualized to permit of much generalization. There are several things that may be assigned as at least partial causes of some of the phenomena exhibited by the fish. It has been noticed that when feeding it will fill itself to repletion and then periods of varying length ensue when the fish will not take food at all. Apparently having become surfeited, it puts in the rest of the time in utilizing what it has acquired. Changes of temperature and barometric pressure and other meteorological conditions may also be assignable explanations, and there may be more truth than poetry in the old rhyme relating to the direction of the winds.

HABITATS.—In the spring of the year the trout begins to scatter and often may be found at almost any point in the lake, its location being controlled by its food supply to a great extent. But as the hot weather approaches it becomes more and more restricted in its movements, until finally it resorts to cool waters of deep holes or cold inflowing brooks. Again in the fall it congregates on shoals or at the mouths of streams which it ascends to spawn. After spawning it gradually works back into the lake and is found about the mouths of streams or wherever food may be found. It is this run-down fish that has been mentioned previously by a correspondent as constituting one of his supposed distinct races.

In an article published in Forest and Stream, November 24, 1900, J. P. Whitney wrote that in December and early January the trout are comparatively plentiful in a few feet of water below the ice, but that afterwards they are mostly in from 15 to 40 feet.

Brooks possessing suitable conditions are occupied throughout the year and sometimes year after year, at least in some portions. While streams tributary to lakes afford nurseries from which the lake receives an annual supply, many trout, continuing small, reach maturity and pass their whole existence in the brooks.

MIGRATORY MOVEMENTS.—Trout are not generally subject to extended migrations, and in the far inland waters, excepting their movements for breeding or seasonal accommodation, they are rather localized in their habits. Near the coast, however, when possible, they often enter the sea, and in certain localities there seems to be a race of almost permanent marine trout, entering fresh water at more or less regular periods. In New England such fish are locally known as salters.

One Rangeley Lake observer, in a communication to a sportsmen's journal, wrote that the trout were not migratory in their habits, although in exceptional instances they would roam about more or less and sometimes go long distances. Otherwise they would frequent the same feeding grounds, although making their usual spring and autumnal movements. He further stated that if a trout was carried away from its accustomed haunt and placed in the water it would return forthwith, thus displaying a remarkable homing instinct. He cited one instance of a trout, known by a hook left in its mouth, which was caught again the next day in its original place, having traveled a distance of 3 miles during a dark night beneath 30 inches of ice and snow.

Mr. Rich wrote[a] that he once saw a school of trout several acres in extent making their way from the headwaters of the lake toward the inlet. They were said to be swimming near the surface and the water appeared to be alive with them. They could plainly be seen from the boat and were of all sizes, some very large ones being among them. He said occasionally one would break water.

The population of tributary waters is mainly brought about by wanderings of young fish which tend to move upstream and into smaller streams after they begin to feed, although adult trout, while in pursuit of food, sometimes gradually make their way into neighboring waters.

BREEDING.—The trout spawns in autumn during the falling of the water temperature, the season varying somewhat with the latitude and also with the local temperature of the water. In general, including all localities and conditions, it may be said to extend from September into December. The duration is about two months for the trout of any body of water. In the Rangeley Lakes the height of the season is from about the middle of October to November, depending somewhat on the conditions and weather. The season may be delayed or interrupted by weather conditions.

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[a] J. G. Rich, American Angler, Apr. 14, 1883.

The sexes differ much in appearance at the breeding time. The head of the male is longer, the lower jaw somewhat hooked, the mouth and teeth larger, and the coloration more brilliant, the belly and some of the fins being a brilliant red, and the white margin of the pectorals and ventrals more distinct. The body also becomes flat or slab-sided and has a thick coat of mucus, almost or quite obscuring the scales. (See Pl. XLIII, Table IX, p. 594.)

The age of maturity varies somewhat. The male is usually more precocious in that respect than the female. Artificially reared trout have been found mature at 1 year of age. A colored picture of a 14-months-old female only 7⅝ inches long, still bearing parr marks and in a spawning condition, is shown in the Manual of Fish Culture issued by the United States Fish Commission in 1900. The usual age of maturity under natural conditions is doubtless somewhat more advanced. As shown in another place, the size of the fish does not indicate its age; therefore, breeding brook residents only 2 or 3 inches long are not necessarily young fish, although possessing parr marks.

According to Livingston Stone, all 2-year-old trout spawn; some yearlings do and some do not; and the main dependence of the trout breeder for eggs is on trout upward of 2 years old. The duration of fertility, which has not been ascertained, is also variable. But very large fish, although found on the spawning grounds, are often old and practically sterile.

Usually there are established breeding places to which the fish resort year after year unless changes of physical conditions occur. The Rangeley Lakes are extremely liable to such changes, which affect both streams and shoals as spawning resorts. Ofttimes lowering of the water exposes the bars that most streams form in the still water at their mouths, thus preventing the entrance of trout, and, of course, shoals in the lake will be laid bare by the same means. In Forest and Stream, October 15, 1891, it was stated by a correspondent that in the Rangeley region the trout had begun to seek their spawning grounds as usual, "But," using his words, "the spawning grounds are not found where they should be. On the contrary, the water has far receded from them and they are only flats of dry gravel, in some instances many rods from water sufficient for trout to spawn in."

In the same paper, January 12, 1888, Capt. F. C. Barker, a lifelong resident and observer of the Rangeley region, wrote to the effect that for years before the Union Water Power Co. modified Mooselucmaguntic Lake one of the largest spawning beds to be found anywhere in the Rangeley region was off the Bemis Bar and in not less than 8 feet of water 40 rods from shore. Year after year they came there and did their spawning, but when the water was raised only 2 feet higher over their bed they abandoned it altogether.

The trout begin to assemble on the shoals or in the streams, as a rule, during September, usually in the latter part of the month, in the Rangeley region, but they are not at this time quite ripe. The run then continues well into October, sometimes later. The fish appear to go in schools, and there seems to be a consensus of statements that the early runs are composed entirely of males. In his article regarding his observations in Kennebago Stream, Mr. Rich stated that the males came first, "cleaning off the stones until they fairly shone in the sunlight." Then they seemed to leave all at once for a day or two, afterwards returning with the females; but a curious fact was observed that while before the arrival of the females the beds were covered with males, afterwards there were but few of them. In his former article he stated that there are always more males than females, sometimes three to one.

In the Rangeley Lakes region, doubtless, the trout spawn on every suitable shoal and ascend every suitable stream when possible. The most famous spawning places are Rangeley, Kennebago, and Cupsuptic Streams and the outlet of Mooselucmaguntic Lake below Upper Dam. Mosquito, Sawmill, and Metallak Brooks are also of importance, and "Beama," or Bemis Stream, has been mentioned in this connection. Kennebago Stream is stated to be ascended sometimes as far as Kennebago Falls, which present insurmountable obstruction, but Capt. Barker stated that the 7 miles between its mouth and the Ash Tree is the usual resort and probably furnishes Mooselucmaguntic and Cupsuptic Lakes 75 per cent of their trout, but another writer in Forest and Stream, November 3, 1894, was of the opinion that nine-tenths of the Rangeley trout spawn in still waters where the water was affected by springs.

With the trout frequenting different shoals or streams, there are frequently differences of size of the fish composing the runs. One locality may comprise small fish, another large ones, the individuals being of more or less uniform size. Regarding this fact, having spoken of the anglers catching out big fish from those coming on to the spawning grounds, Mr. Rich wrote:

> I am now referring to the largest brook trout, which run together in masses, all nearly the same size, or at least of 2 pounds weight and upward. One-pound trout, as a rule, spawn in entirely different localities and by themselves and commonly earlier in the season by some weeks. This is not, however, exclusively so, for many 1-pound trout are often mixed with larger ones on the spawning grounds.

In American Angler, vol. VI, November 8, 1884, p. 297, Mr. Rich graphically described the first run of trout in the Kennebago River in 1884, where, he said, from the last of September to the freezing of the river in November, the trout resorted to spawn. He wrote that on September 22, having been attracted by the splashing of the water, sounding "like a drove of moose wading in the river," he saw a large school of trout, many of which were of large size, jumping out of the water and going through various maneuvers as they made their way up the river. They continued to run in large schools until all the spawning beds up along the river were fully occupied. He said that the number of trout running up the river could not be estimated, but that in the small space of about 5 rods the spawn takers secured 500 trout from October 1 to 12.

By flapping away the sand and dirt the trout form shallow hollows in the gravel, which serve as nests in which the eggs are deposited and covered with gravel or pebbles.

Mr. Rich (loc. cit.) stated that the beds were made of small round pebbles piled up in heaps, 3 or 4 feet across, and that these pebbles were carried in the fishes' mouths, sometimes quite a distance. The beds accumulated sediment and river muss during the year, and when the time for spawning drew near the male trout congregated near the spawning grounds in great numbers and cleaned the beds and made them as bright as if they had been polished. The fish then retired and in some ten days or two weeks returned with the female trout in large schools, which lay around in the vicinity of the beds until their time of deposit arrived.

While most of this statement is doubtless correct, Mr. Rich apparently mistook old chub nests for those of the trout, due perhaps from having observed the trout utilizing them. He may have guessed that the trout carried the pebbles to the heaps in their mouths. In another article regarding nests in Kennebago Stream he stated that his observations there afforded no reason for changing his views of the manner of trout spawning except that the beds there appeared to be flat and formed of small cobbles.

The spawning process is thus described by Mr. Rich:

> The female drops some spawn, then with a dexterous movement of her under fin turns a pebble over it, whirls back and forth around the bed a minute, and then goes through the same operation again, the male occasionally sidling up to the female and both touching bellies together for an instant: then the male leaves her and looks after the spawn, and if he finds it he gobbles it up. The above operation is continued for many days, until the female has deposited all her ova.

The eggs are not all emitted at one time, but a female trout, usually attended by one and the same male, occupies the nest for several days. Mr. Rich says (loc. cit.) that if the female is taken from the bed the male will leave, but if the male is removed the female will remain and ere long another male will take the place of the one removed.

Trout are not infrequently observed with ripe spawn out of season, during almost any month of the year. A writer in a sportsmen's journal in 1894 stated that in the Rangeley region well into January he had observed through the ice trout spawning, and that in August not long before he had caught a pregnant 7-pound fish from which spawn was dripping. The fish was said to have been caught by slow trolling with worm bait in about 30 feet of water. The writer once caught, in early June, a 2-pound trout that contained ripe spawn.

The eggs vary in size, but are usually one-sixth of an inch in diameter. The number yielded by one fish depends on its size and age, yearlings usually producing from 150 to 250; 2-year-olds, 350 to 500; and older fish, 500 to 2,500.[a]

Regarding the number and size of the eggs, Livingston Stone stated:[b]

> The number of eggs to a fish is given as 1,000 to the pound, but it is often more than this and varies much with the size of the eggs, those having small eggs yielding the most in number. I have taken 1,800 eggs from a pound trout, and once took over 60 eggs from a trout that weighed just half an ounce immediately after being stripped.
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> The eggs of the trout are large compared with those of most fish, except the salmon. They average about three-sixteenths of an inch in diameter, varying very considerable in size, the very largest containing probably twice the bulk of the very smallest.
>
> They are sometimes colorless, sometimes orange hued, and sometimes have a rich-red tint. The cause of the variation in the color of the egg is not positively known. It has been thought to be hereditary.[c] It has also been attributed to the color of the flesh of its parent, and to the nature of the parent's food.[d] A correspondent of Mr. Buckland says that the tints can not depend on the color of the parent's flesh, because all graylings' eggs have similar tints and all graylings are white-fleshed.

The eggs are hatched in the spring, the time being determined by the temperature of the water. Warm water hastens and cold water retards the hatching.[e] After it is hatched the young trout lies concealed amongst the gravel until the yolk sac is absorbed, when it is capable of feeding. Then it gets into shoal water along the stream's margin or on the ripples, and whenever possible into rivulets and other small waterways. It ascends such places for considerable distances.

GROWTH AND AGE.—A correspondent of Forest and Stream, June 23, 1887, asked the questions "What causes the *Salmo fontinalis* to grow to such a size in the Androscoggin waters? Why are not the trout as large in Moosehead and other Maine lakes?" Then he proceeds to answer the questions himself: "Cut open the maw of one of the great trout and the question is answered. There you will find minnows in several stages of digestion, from the one just gulped down to only the backbone of the first one eaten. It is the feed. Millions of the chubs, Cyprinidæ, are there for trout to eat. It is probable that these numerous Cyprinidæ are increasing faster than the trout."

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[a] Manual of Fish Culture.

[b] Domesticated trout, how to breed and grow them. Sixth edition, 1901.

[c] Massachusetts, Fisheries report, 1868, p. 31.

[d] Fish Hatching, Buckland, p. 19, 20.

[e] Under artificial conditions the time necessary for the development of the eggs has been found to vary from about 125 days in water at 37° F. to 50 days in water at 50° F.

The foregoing explanation to the effect that the food is the main cause of the size attained is doubtless true, but the inference that an unusual abundance of food in the Rangeley Lakes resulted in fish larger than elsewhere in Maine was not well founded. In some other Maine waters—Moosehead, for instance—such food as he mentioned is fully as abundant, with some additional species. Still other lakes are even better supplied. The probabilities are, too, that trout fully as large as those of Rangeley are taken or at least occur in other Maine waters, although the Rangeleys still hold the cup for the record fish. In Square Lake not many years ago a trout of 10 pounds was caught, and the writer has personal knowledge of one of over 11 pounds taken not long ago in Belgrade Lake.

The fact is that the Rangeleys have been before the public for a longer time and the records of big fish have been made public. Less famous waters have doubtless afforded local fishermen at least as large fish as ever were authentically recorded from the Rangeleys, but public attention has not been called to them.

However, it is, as the correspondent said, due in great part to the food. But combined with plenty of available food must be room in which to grow. For some reason or other there seems to be a necessity for range. A trout will not attain a very large size in restricted quarters, no matter how much food it has.

The large size attained by the Rangeley trout naturally aroused interest regarding the age of the large fish, and there is a tradition that when Prof. Agassiz was asked how old the big Rangeley trout probably were he replied that no man living could tell; they might be 10 or 200 years old.

Forest and Stream, November 1, 1877, describes an experiment undertaken by George Shepard Page, president of the Oquossoc Club, directed toward learning something of the rate of growth of trout in Rangeley Lakes. Platinum wire was cut into 1½-inch lengths, flattened at one end, and various numbers stamped thereon from ½ to 4, also the numbers 70, 71, 72, etc., to denote the year. As trout were captured they were weighed, one of these tags passed through the skin just under the adipose fin, securely twisted, then the fish liberated. In the course of two or three of the years named a large number of these trout were labeled. In June, 1873, one of them was reported; a trout weighing 2¼ pounds was caught and found to bear a tag marked "½–71," showing that this particular fish had gained 1¾ pounds in two years. No further notice of the results of this tagging appears to have been published.

As previously stated, trout grow faster and larger in the larger bodies of water when food is plentiful than in smaller or more circumscribed places. Given plenty of room and plenty of food, it is a question to what size a trout might not attain. There are at least two natural conditions aside from those of environment just mentioned that probably affect trout. There is, doubtless, a natural size limit beyond which the trout could not go if it lived to be 200 years old. But even if there were no size limit, the species doubtless has a more or less definite life tenure that would in any case limit its growth.

The comparatively recent development of the study of scales has shown that rarely, if ever, is a greater age than 10 years attained by European trout (*S. fario*), and probably not that; the lake trout of Scandinavia probably not over 12 years.

Allowing, then, an average growth of 1 pound a year, as suggested by Mr. Page's experiment, the record fish would be only 12½ years old. It is quite probable that trout seldom live longer than 12 or 15 years.

Seth Green stated[a] that trout differ in size and growth in nearly every locality and then again the speckled trout which inhabit lakes are known to attain a larger growth than the speckled trout of the streams. He said that from careful measurements of brook trout from Caledonia Spring Creek he had found that a brook, or speckled trout, when first hatched is nine-sixtenths of an inch long; at six months old, 2 inches long; at one year old, 4½ inches long; at two years old, 6½ inches long; at three years old, 8 inches long; at four years old, 9 inches long; at five years old, 10 inches long; and at six years, 12 inches long. After they have reached the age of six years their increase in length is usually very slow, but, like old men, they increase in breadth and thickness. These measurements are a fair average, but fish are like people and animals—some grow faster than others under the same conditions, and frequently a 2-year-old trout will be as large as a 3-year old.

In Forest and Stream, June 30, 1887, page 495, some one writing under the pseudonym of "Percival" gave the following formula for ascertaining the approximate weight of normally shaped trout:

$$W = \frac{L\ G^3}{1{,}000},$$

in which W equals weight, L equals length from eye to root of tail (not total length), and G equals girth, which, as the formula shows, should be cubed. The result is the weight in ounces. In fish up to, say, 5 pounds, this is extremely close, in larger fish it of course, is liable to slight differences, increasing as the fish departs from normal form. As an illustration, he said: "Applying this, now, to some of the fish whose measurements and weights are given by Mr. Page, say, for example, his own trout, which was 30 by 18 inches, and subtract a reasonable amount for nose to eye and tail (for the length was, of course, total), we find the weight 10½ pounds, which is close to Mr. Page's figures. Applying it to Mr. Grote's trout, we find it about 8½ pounds, which is what the fish must have weighed." (See p. 553.)

LARGE TROUT.—The size which the trout might attain was for a long time a subject of disputatious and argumentative discussion. Hallock mentioned one from the Nepigon River that was said to have weighed 17 pounds. In newspapers and sportsmen's journals even greater weights have been reported from other localities, some of which were in Maine. The largest trout reported from the Rangeley Lakes was one of 24 pounds, said to have been taken in 1872 by a boy, who had left his hook baited with a minnow in the water over night. In connection with the account of this fish, others of 17, 15, and 12 pounds were alleged to have been subsequently caught. Such records undoubtedly were based upon mistaken identification or misinformation.

In American Fishes G. Brown Goode stated that the brook trout seldom exceeded 2 or 3 pounds and a 5-pounder was thought a monster. He referred to the Rangeley

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[a] American Angler, vol. III, May 16, 1885, p. 312.

Lakes as a famous locality for large fish and mentioned one obtained by Prof. Agassiz in 1860 that weighed 11 pounds.

In 1905, in answer to an inquiry by Maine Woods, State Fish Commissioner H. O. Stanley stated that the largest trout he had ever seen taken in Rangeley waters and weighed, was caught by Luman Sargent, an Upton guide, which tipped the scales at 11½ pounds. The next largest was one that he, himself, had caught which weighed 10½ pounds. Mr. Stanley said that this was the famous fish that George Shepard Page took to New Jersey. Mr. Stanley continued that in his "boyhood days more than 60 years ago" he had seen larger fish that his father used to bring home from those famous waters in the fall. The fish were not weighed, having been dressed and salted when they were brought home, but as he recalled them they looked more like codfish than trout. He said that he had no doubt but that larger fish than the first two mentioned had been caught, but he had never known one to be weighed.

The records and data referred to in the following pages were compiled from Forest and Stream, the American Angler, and Maine Woods. Back numbers of the latter previous to 1903 were not available, but it supplements the other two, which about that time ceased to publish regular accounts. The information is probably far from complete, excepting, perhaps, that relating to the very large fish. Probably all fish above 9 pounds of weight that have been caught since the first issues of Forest and Stream have been recorded and probably most of those of 9 and 8 pounds taken by anglers; in other words, those that were large enough to attract attention in a region noted for large trout.

Aside from the fabulous monsters previously mentioned, no authentic record of a Rangeley trout above 12½ pounds appears. There are four records of Rangeley Lakes trout weighing from 12 to 12½ pounds, of which only two are authentic, the others being more or less uncertain estimates. All but one of these were taken on the spawning beds, and the exception is a 9½-pound fish reported as weighing 13 pounds.

The first was the one caught by Mr. Stanley, with which George Shepard Page's name has been associated. Concerning this fish, Mr. Page wrote in Forest and Stream, June, 1883, that in 1867 he carried alive to his private pond in New Jersey a female trout weighing 8⅜ pounds and a male that weighed exactly 10 pounds. They were weighed after they had been three weeks in captivity, during which time they had eaten nothing. In Mr. Page's words, "They had endured the discomforts of 9 miles across Rangeley Lake in a fish car which contained 43 brook trout averaging 5 pounds each, 35 miles by wagon road, 400 miles by railroad, across Boston and New York by express wagon, and 2 miles by wagon in New Jersey. Describing this experience on one occasion to the late Prof. Agassiz, I inquired what they probably lost in weight. He replied, 'The male trout at least 2½ pounds and the female 1½ pounds.'" This would make them 12½ and 9⅞ pounds, respectively. The male trout was 30 inches in length, 18 inches in circumference, and 11 inches in diameter. In Forest and Stream Mr. Page later stated that the male fish weighed after death 10 pounds and 1 ounce and that according to Stanley and Atkins it would weigh approximately 12 pounds.

This weight was not equaled until 11 years later, when two men dipping blueback trout, in October, 1878, caught two trout, one of which, a female, according to Commissioner Stanley, weighed 12 pounds and a male that weighed 10½ pounds. Both were returned to the water. This is possibly the record referred to by Capt. Barker in a letter to Forest and Stream under date of March 28, 1886, in which he said: "As far as I know, the large trout taken near Rangeley Dam a few years ago by the men fishing for breeding purposes still stands at the head of the list of our large trout. I did not see the fish weighed, but a man who did told me this afternoon that the weight was an honest 12 pounds 2 ounces."

In September, 1879, another large trout was heralded in the papers as weighing 12 pounds, caught by a Mr. Marble and his guide, Steve Morse, of Upton, at Upper Dam, September 30. A correspondent of Forest and Stream who saw the fish weighed stated that its actual weight, taken some time after the fish was caught, was 11¾ pounds.

Forest and Stream, July 8, 1886, published the following:

> *The biggest brook trout.*—We have to record the capture of brook trout weighing 12½ pounds by Mr. J. Frederic Grote, of 114 East Fourteenth Street, New York City, in Mooselucmaguntic Lake, Me., on June 11. The fish was a female, and Mr. Grote kept it in a car for one week, when it died. It was weighed several times at the Mooselucmaguntic House in the presence of John Schultz, of Philadelphia, and the proprietors, Messrs. Crosby and Twombley. It was 26½ inches long, 17¾ inches girth, 7¾ inches deep, and 4 inches thick through the back. The guide was Jerry Ellis. * * * We believe this to be the largest brook trout yet recorded.

In Forest and Stream, June 23, 1887, George Shepard Page wrote in comment that C. T. Richardson informed him that the trout was one that Jerry Ellis, Mr. Grote's guide, called an 8-pound trout, but did not weigh it. After the entrails were removed, having been in the car four days, it weighed 8½ pounds. Commissioner H. O. Stanley estimated the weight as 8½ or 9½ pounds, basing his estimate on the known weight of one of the same dimensions.

Of trout weighing 11 pounds and over but below 12, the one previously referred to, 11¾ pounds, caught by Steve Morse, guide to Mr. Marble, was taken September 29, 1879, and reported as a 12-pound fish. Doubtless 11¾ pounds is authentic.

June 7, 1887, Dr. S. J. Mixter, of Boston, caught, by deep trolling with minnow bait, three trout of the respective weights of 11¾, 9½, and 6 pounds. In answer to an inquiry by William C. Harris, publisher of the American Angler, regarding the largest fish, C. T. Richardson stated that he saw the trout weighed after nearly 1 pint of spawn had run out of her and the stated weight was absolutely correct. This record is almost entitled to enter the 12-pound class. As it is, however, it is the largest fish caught on a hook and line by an angler during the fishing season in the Rangeley Lakes. Its length was 27½ inches; depth, 8½ inches; thickness, 4 inches; girth, 20½ inches.

Of trout weighing from 10 pounds, inclusive, up to 11, there were 15, of which two of 10 and 10½ pounds, respectively, were taken on the spawning grounds in 1867; one of 10, also a spawner, taken in 1873; two of 10 each, also spawners, in 1878; one of 10¼ and one of 10$\frac{9}{16}$, taken in September, 1885, the latter having been caught by John Prentice near Brandy Point. Regarding it the editor of Forest and Stream stated that it was the third largest. One that weighed 10⅝ pounds nine hours after it was caught was taken in June, 1886, by Dr. Charles Haddock, of Beverly, Mass. It was said to be a "clean-cut, perfectly symmetrical fish 28½ inches long and 16½ inches girth." This fish was again reported in Forest and Stream of July 27, 1895, with exactly the same data, as having been caught that year. In 1888 one of 10½ pounds was taken in August, and another of 10½ in May, 1890. One of 10½ was taken in

June, 1897; one of 10 in May, 1898; one of 10 in May, 1903; one of $10\frac{3}{16}$ July 30, 1907, by Capt. S. Z. H. Slocum, U. S. Army; and one of 10 in May, 1908.

Of fish ranging from 9 pounds upward, but not including 10 pounds, there are records of about 30, of which the largest was 9¾, caught in May, 1901. Two others almost as large, $9\frac{11}{16}$ each, were caught in September, 1897, and June, 1906, respectively. Nine of 9½ pounds each are mentioned as having been caught October, 1877 (for fish culture); October, 1878 (for the same purpose); August, 1883; June, 1884; September, 1885; June, 1887; September, 1897; July, 1910; and May, 1911. Five of 9¼ pounds each were taken, respectively, in October, 1873 (for fish culture); September, 1884; September, 1885; April, 1896; and September, 1897. One stated to weigh over 9 pounds was recorded for May, 1890, taken on a fly at Upper Dam. One of 9⅛ pounds was taken for fish culture in October, 1878, and one of the same weight was caught in September, 1892. Eleven or more of 9 pounds, taken at spawning time, have been recorded.

Over 60 weighing 8 pounds and over and less than 9 pounds are authentically recorded, of which not more than a dozen were fish-cultural records.

The foregoing reveals that of trout ranging from 8 pounds to 11¾ or possibly 12 pounds not over 75 were recorded as caught by angling in open season in a period of over 40 years.

TROUT AS A GAME FISH.—By many anglers the trout has always been regarded as the paragon of game fishes. It is, however, due to an ensemble of attributes rather than to any particular quality. In certain points it is far surpassed by other fishes. The black bass in some ways requires more concentrated attention to effect its capture. In point of activity there are several northern fishes that are equal to or excel the trout. The fresh-water salmon will arouse more excitement by its evolutions and tactics, and the whitefish, pound for pound, surpasses them all in every way. The bass, the salmon, and the whitefish all are leapers. They leap when first hooked, and they usually continue to leap until free or wearied by excess of energy. The trout seldom leaps from the water except when rising to a fly, and never more than once when hooked and not often that once. Sometimes when first hooked in trolling the fish will go into the air, then its action is one of dogged pulling and shaking. The writer has heard of but a few instances of trout leaping after being hooked. Once the writer caught a 2-pound trout on a small combination of spoon and fly, and when the trout struck and was hooked it went out of the water. In one of the sportsmen's journals some one described the catching of a 7-pound trout in the Rangeley Lakes. It was stated that the fish jumped full length in the air. At the time there was 100 feet of line out, and it took almost an hour to land the fish. It was stated of the 9¼-pound trout caught September 1 by Thomas Barbour that it was taken on a white-tipped Montreal No. 2 fly with a 4½-ounce rod and that "Mr. Barbour worked one and one-half hours from strike to finish before he had the big fellow reduced to possession."

There is, then, an inexpressible something in the trout besides activity or those qualities which are usually regarded as gameness that makes it such a general favorite.

FISHING PLACES.—The fishing places are not the same for all times of the year. They are also different for the different methods of angling and are affected by the height of water. In the main, the enumeration by J. G. Rich holds good to the present day, notwithstanding the many changes in physical conditions. However, some of the places named by him are now closed to fishing.

Generally, from the 15th to the 20th of May trout are abundant at the mouths of brooks and rivers, as well as in eddies at the foot of all rapid waters where there is a deep hole, and later in the white water. By the latter part of May, according to Mr. Rich, trout are distributed all over the lakes, and any novice could easily secure a good string. Particular mention was made of the narrows and the rapids of Kennebago and Rangeley Streams for large trout. He named Indian Rock and above on Rangeley and Kennebago Streams as good pools with plenty of trout. These places were stated to be particularly good in September.

It was said that in August and about the 1st of September large trout are found off the long sand beach near Bemis, where all fishing was done from boats. Excellent fishing in June and the last of September, of about 1-pound trout with occasionally larger ones, among the islands 5 miles down the lake was mentioned. Eight miles down the lake and about 2 miles above Upper Dam, at Brandy Point, the largest trout were found. Bugle Cove and Trout Cove in Mooselucmaguntic Lake afford many records of large trout.

The pool at Upper Dam is famous for the large trout, numbers of them, and fly fishing. This pool is estimated to be 300 feet long and 200 feet or more in width, with a strong current through the middle, making two strong whirlpools, one on the right and one on the left. The fishing is done mostly from boats either at the mouth of the pool or on the back waters. It is probably this pool that was referred to by Mr. Rich as the inlet of Richardson Lake, where, he says, good fishing may be had almost any time, but especially in June and September.

Mosquito Brook is stated to have been a famous place.

Off Metallak Brook, where the water deepens, was favorably mentioned as a good place. In the vicinity of this brook is a continuous sand beach, and some distance out from shore the shallow water makes suddenly off into deep water, forming a steep bank. Near this bank, in an area of perhaps one-half a square mile, was a good fishing ground, where trout congregated and stayed winter and summer. This location, being at the upper end of the narrows connecting upper and lower Richardson Lakes, where there is supposed to be more or less current, forms a natural fishing point, which was not generally known to the people or the guides but was known to the Indians in old times.

Down the narrows, 1 mile from Metallak Brook grounds just mentioned, was the famous Cedar Tree Point, mentioned as an October, November, and winter fishing ground. These months are now out of season. But still farther down the narrows, where the lower lake begins, was a famous place for large trout in the spring. Some days they would rise to a fly, but usually, as in most deep water in June, the method was baiting and sinking.

Next in order mentioned by Mr. Rich was Middle Dam, at the head of the outlet into Rapid River, where the largest trout were taken.

As already stated, in the general fishing season trout are caught in some way almost anywhere—from wharves, off points at mouths of streams, and about shoals. Certain special places mentioned are resorted to when the fishing is not so widespread and the fish are more or less congregated for one reason or another. Sometimes such grounds, perhaps through some of the previously mentioned changes of conditions, are unproductive. Then it is that the complaints of poor fishing arise. Even then, according to the experienced, good fishing is possible to those recognizing the cause by searching for similar places elsewhere. In August, 1899, one angler of many years' residence at the lakes stated that he had most remarkable luck taking fish from grounds that he had never thought of before, and later in the same year said that there were more trout than ever and that they were to be had by those who know where to go and how to take them.

METHODS AND TIME OF FISHING.—The methods of fishing in the Rangeley Lakes may be classed under three general heads—trolling, fly fishing, and bait or still fishing, locally known as "plug fishing." It is unnecessary to describe these methods. Under bait fishing, however, it should be said that the ordinary fishing from shores or wharves with bait is not classed as plug fishing, which is bait fishing in deep water. It is necessary to note this distinction in the discussion of plug fishing.

The fishing at these lakes begins with the disappearance of the ice in the spring. Then it is mainly by trolling until well into June and sometimes later. Fly fishing is variable in the time of its opening, but usually begins with the first real warm weather and the presence of insects on and over the water. Fly fishing ceases with the warming of the shore and surface water to such a degree that it is uncongenial to the trout. Then the fish resort to cool waters, either at some depth or at the mouths of cold streams. At this time some resort to plug fishing, which is the usual method during the warm summer months. When the weather begins to cool, fly fishing is resumed and used to be at its best during the month of September when the fish were congregating on shoals and at mouths of streams preparatory to spawning. However, any one of these methods may be successful, according to conditions and circumstances, at any time of year.

There are those who visit the lakes for trolling only. When the fishing by that method declines they leave. Others first fish by trolling and stay for fly fishing. Still others would scorn any other method than by the fly at any time, but they are few. It has been stated that the trolling season begins about the time the ice leaves and that its duration is variable. It has elsewhere in this paper been noted that on several occasions it lasted well into July. Regarding the size of the fish caught by this method, there seems to be no limit either way, excepting in the size attained by the fish and in ability to take the bait into its mouth. One six days' trolling record in June was 32 trout weighing 85 pounds, from 1 to 7 pounds each. Another one-day record, April 25, 1896, was thus stated: "Caught by trolling a bunch of worms at the end of 50-foot line, one trout of 9 pounds flat and another 9¼. This spring hundreds were caught in this way ranging from 1 to 5 pounds."

A sportsmen's journal correspondent writing under date of June 9, 1882, in regard to fine catches of large trout, stated that most of the trout had been taken with worms and minnows. The previously mentioned alleged 12½-pound trout, afterwards decided to have weighed not over 9½ pounds, was stated to have been caught with a minnow bait in deep water.

Regarding the method of trolling, while it is effective, it subtracts much from the gameness of the fish, especially when sinker and gang hook are used, and the fisherman loses much from the sport by the stiff trolling rod usually employed. The method par excellence, the praises of which have been sounded in song and story, is fly fishing, and while from the time of the jig and spear there have been fly fishers they seem to be increasing in number, and some who in the old days would not have hesitated to jig a trout that could not be secured by other means now have abandoned all other methods and catch the trout by fly alone or not at all. Mr. Rich, writing under date of October 1, 1880, stated that trout of the largest size could, and now can be, seen lying upon their spawning grounds, but they charily rise to the fly. The most of those taken are baited with spawn, although many parties will not deviate from the more sportsmanlike way of fly hook and delicate rigging.

As long ago as 1887 a correspondent of the American Angler wrote:

> The character and modes of both fishermen and fishing have greatly changed during the past 10 or 15 years; formerly most who visited the region fished either by trolling or "plug fishing" (from an anchored boat over a place baited to attract the fish). As an illustration, permit me to mention the fact that the first time I saw one of Maine's most distinguished Senators of a score of years ago he was "plug fishing" for the greater part of the day, but now, no doubt (for he still lives), he would scorn the idea of using anything but a fly. Scarcely a fisherman now goes out to troll without taking his fly rod with him, while many never think of using anything else, and we trust the day is not far distant when all other modes of trout fishing will be abandoned.

The season for fly fishing also varies, but, as previously stated, it begins in general at about the decline of the spring trolling. Regarding it, an experienced angler, under date of June 10, 1893, wrote to a sportsmen's paper:

> The height of the trout season in Maine waters is over so far as the spring season is concerned, and many of the parties have returned and are returning. Still, there are others who will go fly fishing purely, and they will follow up all of the month of June and well into July. There will then be a lull till late in August, or during the heated term, after which the fall fly fishing will begin.

The earliest date of the opening of the fly-fishing season was mentioned in a letter dated May 23, 1898, to a sportsmen's paper, in which it was stated that at Mill Brook one person took 30 trout on a fly in one day, early as it was, and that it seemed that the trout began to rise as soon as the smelts were done running. The next earliest was mentioned under date of May 30, 1891, when it was said that trout had just begun to come up to the fly at Upper Dam, and the same was true of the upper lakes, but up to that time the weather had been unusually cold. On June 1, 1877, at Upper Dam it was reported that the trout had commenced rising finely to the fly, and about 50 fish had been taken in that manner in the previous 24 hours. On the other hand, on June 10, 1882, it was stated that there was no fly fishing owing to the retarded season. On June 7, 1889, trout and salmon were reported to be rising to the fly.

The fishing is mentioned in July as follows: July 9, 1874, many under 3 pounds were taken on flies. This, however, probably refers to the last of June fishing, at least in part. July 10, 1899, it was stated that the fishing continued better than usual after the hot weather came in, although there was the same complaint that trout did not rise to the fly as readily as in former seasons. Still, there had been some fair fly fishing at the Upper Dam and at other places. On July 17 of the same year it was reported that a good many small trout had been taken on the fly at Haines Landing and at Bemis; and again on July 22 it was said that fly fishing was holding out well. On July 26, 1899, a report was to the effect that at Mountain View trout were just beginning to rise to the fly and at sundown when flies hovered over the lake the trout fairly jumped out of the lake to catch them. On July 28, 1892, there were reports of remarkably good fly fishing on the large lakes after the water began to fall. At Upper Dam, for the week previous, fly fishing had been the best of the season.

A report dated August 14, 1905, stated that during the previous 10 days over 20 trout and salmon had been taken on the fly, most of them weighing over 2 pounds but all under 3 pounds; and on August 30, 1876, it was reported that trout were rising to the fly very handsomely.

September 21, 1901, fly fishing was reported good, and on September 26, 1905, it was stated that there was excellent fly fishing from the wharf in front of the Mountain View Hotel, and more than 100 fish had been taken there, but it was not stated whether they were trout or salmon. The first of the large trout taken by Commissioner Stanley at Upper Dam in 1878 was on September 22. Trout were caught throughout September and until October 10, inclusive.

It is stated that the largest trout taken on the fly were caught in September, but large trout have been taken on the fly at other times, and doubtless many of the records not definitely stated as taken on the fly were so caught. The largest so taken by any angler is one caught by the late Senator Frye, that weighed slightly over 10 pounds. So far as the available published records show, the next in size, one of 9½ pounds, was taken at Upper Dam by Thomas Barbour in 1897. Other records are of September, 1874, one of 7 pounds; August, 1876, two of 5 pounds and some of 1½ to 3 pounds. In September, 1885, one angler caught one of 4, one of 7½, and one of 8½, and three others got one each of 5½, 7½, and 9½ pounds. J. A. French furnished and vouched for the correctness of a list caught at Upper Dam on a fly in August and September, 1890: August 29–31, 6½, 6¼, 4½, and 6¾; September 1–30, inclusive, $8\frac{3}{16}$, $6\frac{3}{16}$, 4, $6\frac{3}{16}$, 9⅛, 6½, 7¾, 7¾, $7\frac{7}{16}$, $6\frac{1}{16}$, $5\frac{5}{16}$, $6\frac{3}{16}$, 6¾, 5, $5\frac{5}{16}$, $7\frac{5}{16}$, 6¼, $7\frac{3}{16}$, 6½, 6⅞, $6\frac{5}{16}$, 4⅞, and 8⅞.

Plug fishing.—As elsewhere stated, the so-called plug fishing is from anchored boat over some deep hole where the fish congregate in the summer months. Oftentimes these places are or have been baited to attract the fish. For many years plug fishing was an approved and favorite method of even those who disapprove of it now. The alleged and apparent, or perhaps it should be said evident, decrease in number of large trout gradually and justly became to be, in part at least, laid to this method. From time to time efforts were made to secure legislation to prohibit plug fishing, but the influential antagonism to such measures defeated them. Therefore, plug fishing has continued, but not wholly unabated. There are sportsmen who will not resort to that mode even if there are those who will not desist. The plug fishing method is due to the fact that, as a rule, trout, especially large ones, could be caught in no other way during the midsummer season, and there were places where trout could be caught throughout the season. Mr. Rich stated that if one wished to catch a big trout in midsummer he must bait and sink in deep water, the usual depth being 40 to 50 feet. Letters to the writer from Daniel Haywood and Daniel Haley, both experienced guides of Rangeley and lifelong residents of the region, stated that still, or plug fishing, was all done in 35 to 40 feet of water with clay bottom.

It was reported that on August 6, 1874, a party of two at Stony Battie, Mooselucmaguntic Lake, took with bait 26 trout that weighed about 30 pounds, and good success was had at Bugle Cove. In 1880 it was authentically reported that on August 20 one man and his guide, fishing from 1 p. m. to 5 p. m., in 30 to 40 feet of water, in Mooselucmaguntic Lake, took 16 trout weighing 52 pounds, as follows: One, 8½; one, 5½; one, 5; one, 4½; two, 4; one, 3½; three, 3; one, 2; and six, 1 pound each. In 1884 an angler, writing on August 9, contributed the following statement to a sportsmen's paper:

> The trout fishing here is something remarkable. Yesterday, August 8, a gentleman took five trout weighing together 28 pounds. A few days before he captured 8 weighing 38 pounds. The only mode

to get these large fish, veritable leviathans in size and nature's jewels in glistening beauty, is by deep-water bait fishing. The angleworm is very catching, and a long line of, say, 60 yards is needed.

In 1896 the following remark by Senator Frye appeared in Forest and Stream:

> From time to time my attention has been called to the fact that in the heat of the summer, when the trout had sought the spring holes for cool water, they were captured by deep fishing with worms and minnows in enormous quantities, all of them killed, many wasted. That this murderous slaughter, in which, I am happy to say, no sportsman participates, has had a serious effect I have no hesitation in affirming, and my knowledge of those waters is certainly equal to that of any other person. If summer plug fishing in Mooselucmaguntic Lake is not prohibited by law, in time serious results will follow.

In the May 7 number of a sportsmen's journal of 1899 a special notice was published, as follows:

> The fish commission is to give a hearing at the Rangeley Lake House, May 17, as to the proposition to close the whole Rangeley system to all bait fishing after July 1 of each year. The summer guests at the hotels will oppose the action, but the sportsmen, who usually fish by trolling in the spring and with the fly in the fall, are strongly in favor of some action that shall stop the taking of trout by what is termed "baiting up" in the summer time. Deep water is selected, and minnows, chopped up, are thrown in for several days in succession. When the big trout have been tolled to these feeding grounds, the hooks are brought into requisition, attached to 50 or 100 feet of line, as the case may require. In this way many beautiful trout are taken that have sought the deep water to escape the heat. The petition to the commissioners is directed more especially to the stopping of this sort of fishing.

FACTORS AFFECTING TROUT FISHING AND THE ABUNDANCE AND HABITS OF TROUT.—Adverse natural and artificial conditions affecting the trout supply and permanent or temporary quality of the fishing have been referred to. Among these may be mentioned the modifications produced by dams, meteorological conditions, number of anglers, natural and introduced enemies, undue and unseasonable fishing, and the introduction and artificial propagation of other species.

Effects of modification of lakes by dams upon trout.—The modifications produced by dams that permit of raising or lowering the water in the lakes are most potent factors in modifying the habits of the fish, as well as at times in fish destruction, directly and indirectly.

Competent observers have, from time to time, called attention to these effects. The general concensus seems to have been that in their permanent and ultimate effects the dams were advantageous rather than otherwise, in that the high water afforded more extensive and protected feeding grounds for trout. But there were some who expressed the view that disaster to multitudes of fish invariably followed the sudden opening or closing of the gates. In 1896 the late Senator Frye wrote, among other things:

> The constant changes in the height of water, making to-day a bar on which to drop a fly, and in a month water over it deep enough to float a gunboat, are disturbing elements. These things only illustrate the necessity of creative and preservative agencies if this fishing in the lake is to continue to be attractive to sportsmen.

Height of water.—As has been stated on another page, in every body of water the fishing varies by the season, by the month, by the day, sometimes by the hour, and even shorter periods. A period of success or failure the angler usually tries to account for, commonly ascribing it to the weather or the height of water. Frequently, too, prophesies regarding the fishing prospects are based upon the height of water in the lakes. Usually such predictions have been favorable, although contradictory at times; the fishing promises to be good because the water is high or because it is low. Again, if it happens to be poor fishing when the water is low, it is predicted that it will improve upon the rise, and vice versa.

As a matter of fact, the character of the fishing depends not upon one condition alone but upon a combination, sometimes of several conditions. Such opinions regarding these points as have been mentioned in some sportsmen's journals have been noted by the writer. The period in which notes referring to height of water and fishing were found extended, nonconsecutively, from 1873 to 1902, representing 15 years.

From these notes it was observed that there were seven stages of high water and poor fishing, nine stages of high water and good fishing, seven stages of low water and poor fishing, and five stages of low water and good fishing. From this it would seem that high water was the most favorable, although both high and low water exhibited the same number of stages of poor fishing and low water somewhat more than one-half as many stages of good fishing, which leads to the repetition of the suggestion that the fishing is influenced by many other conditions besides the stage of the water.

Weather.—From time immemorial the weather has been believed to be the most powerful controlling influence affecting fishing. As it affords an ever-ready topic of conversation when there is nothing else to talk about, so it serves as an excuse for poor luck in fishing or good catches, as the case may be. Probably this is based to a great extent on solid ground, but oftentimes the adverse effect is on the angler rather than the fish. However, there are, without doubt, early, late, and unfavorable seasons that may be correctly ascribed to meteorological conditions. Also, sudden changes affect the fishing one way or the other.

As shown by the ice records, the opening of spring is variable. Some seasons the cold weather may continue well into the summer, with only now and then a warm day. Again, it may be hot early, and dry and hot weather last all summer and fall. Again, there is often a wide range of conditions within a very short space of time, as, for instance, a weather record in 1903 was to the effect that on April 29 the thermometer at Bemis registered 70° F.; April 30, 69° F.; May 1, 31° F. at noon, and spray from the waves would freeze in icicles on the bushes near the lake shore; while May 2, at 4.30 p. m., the mercury stood at 20° F.

Of 34 reports to various sportsmen's papers regarding the quality of the fishing which was referred to the weather conditions, there were 14 of cold weather and good fishing, 4 of cold weather and poor fishing, 2 of hot weather and good fishing, 4 of hot weather and poor fishing, 2 of hot weather and poor fishing changing to good fishing with cold weather, 1 of cold weather and poor fly fishing, but good bait fishing, 1 of the first warm day of the season affording the first good fishing, 1 of cold but warmer with the best fishing for years, 1 of fair and warmer and good fishing, 1 of fine weather and fine fishing, 1 of good weather and good fishing, 1 of best of weather and best of fishing, and there was one report of a backward, cold season with poor fishing followed by a continued hot spell and poor fishing, with a complaint that the fishing was playing out.

The foregoing reports signify very little, for some of them come from those who fish by trolling, others from fly fishermen, and perhaps others from bait fishermen, and some of them state the conditions, perhaps, affecting all kinds of fishing. As a rule, during cold or very cool weather fly fishing is rarely good, while trolling is at its best.

When warmer weather and fly fishing begins, which is perhaps as much due to the presence of flying insects as the weather, the trolling, as a rule, ceases. And there is a period during midsummer when usually the only successful method is by deep-water bait fishing, locally called plug fishing. However, throughout the season—any season, in fact—if the angler fishes in the right place at the proper time of day he may catch some fish by any one of the methods mentioned. But the disagreeable conditions known as hot and cold, windy and rainy, disincline many anglers to prolonged attempts to find fish, and the attractions of hotel or camp outweigh the inclination to catch fish when to do so necessitates early rising for morning trolling or a long boat ride in the hot sun to a fly-fishing ground where the fish rise to the fly only in the first evening dusk. Therefore, as previously stated, much depends upon the angler as well as upon the weather, and good or bad weather fishing reports result accordingly.

Number of anglers.—Various conditions affecting the fishing, or that may affect it from time to time, have been mentioned. No one of these necessitates a constant progressive diminution. One factor not previously mentioned that would tend in that direction unless it were safeguarded by enforced restrictive and limiting laws is that of numbers of fishermen.

Prior to 1891 no railroad extended nearer to any of the Rangeley Lakes than Bethel, Rumford Falls, and Farmington. From those stations the angler was obliged to travel by stage and buckboard, and in some instances on foot a part of the distance, for 20 or 30 miles or more. Even then a great many anglers annually visited the lakes. The region became famous for its numerous large trout, and an increased number of anglers were attracted by the fishing. As the number of visitors increased, accommodations increased accordingly, and the lakes became more accessible by improved roads and extension of railroads. As early as 1883 it was stated on good authority that the number of visitors annually frequenting the Rangeley Lakes then reached the large number of 3,000, to accommodate whom capacious hotels, camps, and cottages had been erected. Since then facilities for reaching the lakes have been increased and improved and accommodations of every character, from unpretentious camps to large, fashionable hotels, as well as almost innumerable private summer residences, have been established, and it is an unusual season when they are not all filled.

In a letter to a sportsmen's journal, dated June 8, 1889, which was before a railroad reached any point on the lakes, a correspondent estimated that there were 1,000 people on the lakes the week before.

Before a legislative committee in 1903, regarding the establishment of a hatchery at Rangeley, an owner of very commodious camps said that for the past four years he was obliged to turn away people who wanted accommodations. Another camp owner stated that there were then 10 sportsmen to 1 nine years previous, when he first went to the region.

It is not necessary to call attention to the possibilities of depletion from unrestricted fishing by an unlimited number of anglers. Artificial propagation and due regard to conservation greatly reduces the danger. Yet, as mentioned elsewhere, there is a limit to the efficacy of artificial stocking of the lakes, imposed by the limitations of biological capacity, the significance of which is that it is possible to conceive of so many anglers that the lakes could not support enough fish to afford good fishing to all; also, that there is danger of deterioration from overstocking, sooner or later resulting in general depletion.

Enemies.—From ova to senility the trout is subject to destruction by enemies. These enemies are many and various, almost every zoological class, as well as some botanical classes, being more or less represented. Bacterial, fungus, plasmodial, and parasitic diseases destroy them individually and epidemically. Nonparasitic, as well as parasitic, worms and crustaceans and some insects are not infrequently fatal. Among the vertebrates certain fishes, batrachians, reptiles, birds, and mammals can be mentioned. Of these, disregarding man, the fishes, not excepting the trout itself, are the most serious. Under normal conditions these are some of nature's regulatory provisions for maintaining those conditions. It is only when normal conditions are disturbed that the enemies become generally harmful.

The normal enemies of trout in the Rangeley waters have probably existed there as long as the trout, and trout existed in normal numbers until civilization interfered with the natural conditions. This interference augmented the numbers of some enemies and diminished the number of others. The increase has been chiefly amongst the fishes, the decrease among the birds and mammals. These natural enemies were not exclusively enemies of the trout, but included other fishes, some of which were also trout enemies. The additional enemies of the trout were not only direct but competitive enemies, thus doubling their injurious effect. Thus, it may be seen that the decrease in birds and mammals can not have compensated for the increase amongst the fish enemies.

As has been seen in the faunal list, the Rangeley Lakes were peculiarly free from voracious fishes such as occur in most other trout waters, even in the neighboring river basins, and some of which were found in the Androscoggin itself but which had no natural access to the lakes. The principal resident enemies were suckers, chubs, eels, and miller's thumbs, and while most of these were, in a way, naturally inimical, they were to some extent directly and indirectly essential to the trout's existence. Eels seem never to have been abundant, at least within the memory of man. The others were not too abundant and were rendered so only by man's interference; that is, by the introduction of other more abundant and more easily obtainable food, thus making the original food, the fishes named, unnecessary, as they were less apt to be eaten, and permitting and promoting a greater multiplication of them.

The directly inimical fishes that have been introduced into these waters are the hornpout, pickerel, and salmon. The effects of their accession are discussed in other places in this paper.

Of the natural enemies, the suckers are particularly harmful on the spawning beds of trout, at least in some places, where they devour the eggs.

The chub is to some extent harmful in that direction but more so in eating the fry, and in this they are not restricted to naturally produced fry, as the following note indicates, and which suggests the advisability of careful selection of the place of deposit for artificially hatched trout. Regarding trout fry planted in Gull Pond, a letter from J. F. Teach, to Maine Woods, dated September 25, 1903, contained the following:

> A few days ago a number of trout fry from the Rangeley hatchery were put in here at my camp. The next morning, observing these fish schooled in dense masses amongst the rocks on the water's edge, Anthony Tibbetts, a guide, suggested catching a few chubs, of which there are multitudes in the pond, in order to find certainly whether that fish devoured trout fry. Twenty-six chubs were taken out accordingly, and every one, large and small, was packed to the lips with these trout.

According to some observers, however, the trout is his own worst natural enemy, and this is, to some extent, true. Mr. Rich said that as soon as the female trout begins to deposit her eggs several chubs, suckers, and small trout appear on each side of her ready to devour her eggs. While those on one side are dispersed by the male, others rush in from the opposite side, and thus it continues throughout the spawning season. Mr. Rich thought it was doubtful if on some spawning beds a single egg escaped, and, he continued, the destruction of eggs by trout themselves is a very serious matter. He said that male trout when caught from the spawning beds are often found with their stomaches full of spawn, but he was inclined to doubt if the male in immediate attendance upon the female participated in the spawn eating, as when caught he is found to be thin and slab-sided and his stomach usually empty. But Mr. Rich stated that on some beds the spawners seem to be without any particular mates, having a half dozen or more males in attendance, the appetites of which do not seem interfered with and which indiscriminately make a mad rush for the eggs as soon as deposited, apparently securing every one. He wrote that he had seen a hundred trout congregated in an area not over 10 feet square and in such close proximity that there was hardly any intervening space; that it was not uncommon in the late autumn, before the ice had made near the shore, to find half a dozen trout digging over the spawning beds for some eggs that may have previously escaped observation; and that in this operation they frequently assumed a perpendicular position, often with their tails flapping above the water surface.

Probably the most destructive bird enemies to trout were formerly the loon, sheldrake or merganser, heron, fish hawk, and kingfisher. All of these, excepting possibly the kingfisher, are now comparatively scarce.

Of mammals, mink and otter were the most destructive, the coon and bear perhaps aiding to some extent. All of these, too, are comparatively rare.

J. Parker Whitney, in the report of the Maine Fish Commissioners for 1896, wrote that next to man he thought the great blue heron was the greatest destroyer of trout at these lakes. He said that this bird was an incessant nocturnal as well as a daily feeder, of inordinate appetite, and although its principal food was chubs and frogs it destroyed a great many trout and would get away with quarter pounders, if not larger. They had no hesitancy in striking and fatally wounding trout of over 1 pound in weight. Yearly he had seen trout swimming about that had been pierced by this bird's bill, and in 1896 he had caught two which were unfit for food, each over 1 pound in weight, having holes as large as pipe stems nearly bored through them from the back. It was a question in his mind if this bird, of which hundreds frequented the shores of the lakes from early spring till the ice, did not, in the aggregate, kill more trout, principally small ones up to one-half pound, than all the fishermen. He went on to say that, aided by the loons, kingfishers, and mink, they undoubtedly did, and added that the mink was a voracious feeder and would destroy large numbers with the greatest ease from congregating pools and breeding streams which feed the lakes.

Destruction by man.—Some of the natural agencies tending toward the depletion of trout waters have already been mentioned. But of all destructive agents man has been, and to some extent still is, directly and indirectly, willfully and unwittingly, the most energetic, most persistent, and most effective. The aborigines resorted to all the means known to them at all seasons to secure fish, and the trout was one of the principal contributors to their support. But the Indian, it is said, never took more than he required, even if possible. But in many instances the paleface proved himself selfish and wanton to a superlative degree. This does not apply to the original white settlers or to the immediate or following generations, but to later incomers, to whom some one has referred as representatives and minions of incorporated desire for gain.

The water-power and lumbering interests apparently cared not whether the spawning grounds of the trout were destroyed by flood or drainage or by the log drive. It was no concern of theirs whether trout were destroyed by suddenly depriving them of water, and they had no interest in whether angleworms or dynamite were used to supply the workman with fish food, or whether it was during spawning time or any other time, as long as "grub expense" was reduced by a supply of free fish. In fact, it was never given a thought, and it was not brought to their attention until almost, or quite, too late to avert the extermination of this fish.

The early inhabitants of the region in the neighborhood of the Rangeley Lakes—and a distance of a great many miles was not remote in those days—were accustomed not only to get their families' winter supply but also a market supply of trout during the fall and winter. It was a common practice to spear them at night by torchlight. Mr. Rich recalled that one night at Trout Cove an old hunter and himself took by this means 100 "beauties," which weighed 600 pounds the next morning.

In 1879, in a letter to Mr. Rich, the former fish commissioner of Maine, the late H. O. Stanley, said he could well remember the time, some 20 years prior, when it was very common to take 100 pounds of red-spotted trout in one-half day's fishing, but since that time the practice of taking them with grapnel, spears, and nets had become common, and the fish were greatly diminished. He recalled seeing at a fisherman's camp, one October morning in 1854, 100 trout, weighing 600 pounds, that had been speared the night before. Mr. Stanley probably saw the catch referred to by Mr. Rich, in which he participated.

It is stated that about 1860 laws were not known and that trout had for years been netted at the head of the river and taken out by the wagonload for the market; also, that jigging them off their spawning beds in the fall was customary.

Along in the eighties it was generally admitted that trout, especially large ones, were decreasing in numbers, and the fact was ascribed by the anglers to various causes, but to no one of them did it seem to occur that he himself might be particeps criminis. One reason for the alleged decrease in big trout given by Mr. Rich was that anglers had found most of the places where trout congregated preparatory to going onto their spawning beds and diligently and persistently fished for them day after day, rain or shine, and took every fish that would rise, and so reduced the schools of big fish.

It appears that spearing, jigging, and dynamiting were not confined to the early depredations, if the allegations of some Rangeley Lakes anglers were true. In 1887 native residents, and even some anglers, were accused of long-standing jigging. Having discussed these alleged practices, a writer to Forest and Stream, in 1888, stated:

> One would imagine that the facts written here would sufficiently account for the poor success fishermen now meet at the lake, but there is one more, far worse than any mentioned, and for which the Water Power Co. is responsible. The workingmen at the dams took the trout in great numbers during autumn from the spawning beds, and every fish so taken means the destruction of hundreds of thousands of their species. They were speared by daylight and by torchlight, dynamite cartridges were exploded in the water, and the fish were destroyed by the wholesale.

It is not only the adult fish that suffer from destructive agencies, but the young are subjected to them almost on every hand. They enter the shallow water of shore and brook to escape their enemies of deep water and are beset by enemies of land and air. There, also, they are liable to perish through change of physical conditions that act rapidly and effectively. The shoals of small brooks, laid bare by hot weather, restrict the young trout to little pools, which later evaporate, and the fish die, being unable to get to permanent pools or into the lake; or, while in the shallow shore waters of stream or lake, the sudden opening of the gates of a dam previously closed for some time leaves the fish confined in the pools, which, if they do not evaporate, often become so warm that the fish perish, or else they become the prey of birds and mammals or even of frogs and snakes.

In small brooks the danger is not alone from evaporation. Freshets are sometimes disastrous. The writer has seen a spring-fed rivulet suddenly swollen by rain until it overflowed onto a wood road, carrying many small trout out into the ruts and wheel tracks, where the fish were left by the comparatively sudden subsidence of the water, and doubtless many that he was unable to rescue ultimately perished.

In Forest and Stream, June 25, 1904, the late E. A. Samuels, of ornithological and piscatorial fame, cited an instance of waste of trout fry in the following words:

> The most remarkable waste of trout fry that ever came to my observation occurred a number of years ago at the Middle Dam, on the Rangeley Lakes, Me. The gates of the dam had been wide open and the water had been running over the lower flashboards the whole length of the dam for several weeks, and in consequence of this abundance of water the river below the dam was more than bank full, the water spreading into the bushes along the shores sometimes several rods beyond the stream itself. In the middle of the river the water was a roaring, rushing, foaming mass, which pitched and tumbled over huge bowlders and ledges in the wildest manner imaginable; but along both shores it was murky and foam covered and there was little motion in it except that which was caused by eddies and small waves from the rushing midstream.
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> As I was standing on the bank one day, busily engaged in casting the fly in the still water above, I was joined by two men whom I afterwards learned were employees of the Lewiston Water Power Co. They had come to close the gates, for a big raft of logs was coming down the lake above and a full head of water was needed. They went about their work at once, and they did it thoroughly, for the gates were not only tightly closed, but new flashboards were put on the dam, and almost every drop of water was held back. As a result of this action the river bed below the dam was emptied of water almost as quickly as would be a basin held in one's hand. The rapidity with which the water dropped was astonishing, and it seemed as if I could in a very few minutes walk about everywhere in the bed of the stream where the water had been, before the gates were closed, from 4 to 6 feet deep. There I found almost countless numbers of small trout, which had been left by the receding waters among the bushes, crevices in rocks, and shoal places, they being unable to escape with the quickly vanishing water. They were little fellows from about an inch and a half in length, and there must have been thousands of them. I never saw such a havoc in my life. How it happened that so many of these small trout had congregated at that point I never knew. They were all nearly of one size and may have been of the season's hatch which had ascended the 5 miles of Rapid River, in which there are a number of famous spawning beds, and had been stopped by the dam; but whatever the cause might have been that brought them there, they reached the dam only to find destruction.

Trout culture at Rangeley lakes.—The Oquossoc Angling Association was organized in 1867, but it was not until 1873 that the first hatchery was erected. This was on "Beama" Stream. In 1877 another was built near the old dam on Rangeley Stream. Regarding this hatchery Forest and Stream in 1883 reported: "This hatchery has been regularly employed and fully 250,000,000 young trout turned into the lake. Many thousand landlocked salmon eggs have also been hatched and the young fry liberated."

While trout were hatched and planted by the Oquossoc Angling Association and other clubs for a number of years, and probably also by the State, no records of the distribution of the trout in the Rangeley Lakes appear until 1895. The following statement shows the number of young fish planted each year in Rangeley Lakes and tributaries, as indicated by available records:

1895	100,000	1905–6	6,000	1910	243,250
1896–1901, inclusive	(a)	1906	157,000	1911	473,000
1902	1,500	1906–7	29,600	1912	323,000
1901–2	15,000	1907	369,000	1913	585,000
1902–3	7,500	1907–8	75,000	1914	407,750
1903–4	10,300	1908	82,400		
1904	[b] 169,336	1908–9	98,800		

The foregoing figures total 2,653,136 young fish, representing a period of 20 years. When all the adverse conditions with which they have to contend before reaching maturity and the low expectancy of life tenure for the majority of them are taken into consideration, this number, if all were planted in Rangeley Lakes, would seem hardly sufficient to supply a large number of anglers with satisfactory fishing or even to maintain the stock. A concrete but impossible example of this inadequacy may be given by hypothetically assuming that all of the fish attained maturity and that the 1883 estimate of 3,000 annual visiting anglers was maintained. Then the 60,000 anglers in the 20 years would average about 44 fish each by catching all the fish.

THE ALLEGED DEPLETION OF TROUT.—Some factors which might have caused any apparent or real diminution of the trout supply of the lakes that have been mentioned:

1. The effects of dams, etc., it has been seen, may have been only temporary or they may have produced permanent effects, either of which would be more or less manifested in the quality of the fishing and give rise to dissatisfaction or apprehension. The high or low stage of water, one of the effects of dams, in either stage, simply high or low, would have little or no direct effect upon the perpetuity of the trout supply and only a temporary effect upon the quality of the fishing.

2. The effects of seasonal or weather conditions would have no direct significance but might have considerable influence upon the character of the fishing.

3. The number of anglers undoubtedly, according to circumstances, signifies potential depletion.

4. Enemies unduly increased in number or effectiveness, without compensating factors, are also of serious significance.

5. Destruction by man, which involves some of the foregoing, as well as many additional elements, is significant of tremendous possibilities in the way of depletion.

6. Fish culture or artificial propagation is effective in preventing depletion in proportion to the adequacy of the effort. The resistance presented by some of the previously mentioned factors, however, might render adequacy of effort impossible and thus serve only to retard depletion. In other words, artificial propagation must be sufficient to offset the losses through adverse conditions and operations. If fish culture continues

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[a] No records.

[b] Statement of number planted with no definite localities given, probably many of them not in Rangeley waters.

to maintain or increase the resistance through fresh supplies of enemies, in the form of salmon, for instance, an expenditure of so much more trout-cultural energy is necessitated, to which there must be a limit.

Most of the foregoing points have been for years mooted questions, but the efficacy of artificial propagation has not often been questioned. In passing, there is one point more relating to artificial propagation that should be mentioned, which is that every body of water has a safety line beyond which artificial stocking becomes retroactive, thus introducing subtle, intimate, and intricate additional factors of depletion involving not only the artificial but the original stock.

That originally the Rangeley Lakes abounded in trout there is no doubt. J. G. Rich, in his article so often quoted in this paper, writing of the old days, stated:

> We had never then heard of pot fishers or poachers, and there had been no law enacted against the taking of trout any way one choose, and we went at it by the quickest possible method. But by and by parties began to come from the cities, and after years of abundance trout not only grew scarcer but became more wary, and finally we got a fish law; but it was years before the free natives of the forest could see the justice of being curtailed in their liberty of when, where, and how they should take them.
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> Every brook, every stream, and every pond and lake was literally full of them. Of course there were proper times to fish at certain places; for instance, at places where ample quantities could be taken at one time none could be had at another time. I have seen the Cambridge River at the foot of Umbagog so crowded with trout rushing up stream that you could almost walk across it on the backs of the fish (if this is a fish story, it is an actual fact). And again in the fall of the year great schools would rush into the mouths of rivers and coves near their spawning grounds, so as to fairly blacken the water, and they were hungry. This was the "border ruffians" pork barrel, and they availed themselves of it. * * *
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> At the first freezing over of the lakes and rivers, at the mouths of small brooks and around certain stony banks in the lakes and near late spawning grounds, hundreds of pounds could be taken in a day, and the hunters were pretty sure to improve these opportunities. Sometimes these trout lay in very shallow water. Many times have I cut through the ice, and the water rushed up thick with mud, and after a few moments the trout began to bite, and a regular rush began, generally of about 1-pound weight, interspersed with individuals that weighed 3, 4, 5, or 6 pounds, and which must have touched the ice with their backs while their bellies rubbed the sand below.

In the foregoing instance some allowance must be made for the enthusiasm that usually is associated with piscatorial retrospection. Doubtless, however, it is a fair illustration of the early abundance of trout in the Rangeley Lakes region, in support of which there are many other authentic accounts. In those days it was the privilege of but a few to avail themselves of such abundance, but, as has been previously stated, with the passing of years the fame of the Rangeley Lakes for their plenteous supply of mammoth trout attracted an ever-increasing number of anglers to the region. At first it appeared that few, if any, failed to secure satisfactory numbers, even if they all did not capture a monster. Large quantities were annually, perhaps it may be said weekly, shipped home by anglers. These, particularly the large ones, were often exhibited in sportsmen's store windows and elsewhere, thus increasing the numbers to try their luck at the lakes. After a while, with increase in number, it was quite natural that some should be disappointed, since, as a rule, the fish are not generally distributed in a lake but congregated in more or less restricted localities, and the places occupied change at different seasons of the year or under certain conditions. These places constitute the favorite fishing grounds. All new comers, as well as the old resorters, went to the same places. The natural results are obvious. Fewer fish would be caught by the individual, not only on account of a division of the spoils, as it were, but even if the fish were no scarcer many fishermen on the same grounds at one time would make the fish wary or actually drive them away. That such conditions obtained, even in the early eighties, is evinced by the numerous complaints of poor fishing and the explanations of it current in sportsmen's journals of that period.

For years there was a general steady complaint pervading the more or less fluctuating adverse and favorable reports regarding the fishing in Rangeley Lakes. Such complaint came not from occasional visitors but from permanent residents on the shores and from persons of many continuous years of experience. On the other hand, there were counter arguments and statements from individuals of the same classes. In evidence of their contention that the fishing was as good as ever, better, or improving, they published the catches of individuals that made an excellent demonstration of the good when no mention was made of the many more who caught no fish.[a] Many of those who claimed that the fishing was not declining were those whose business interests were at stake, depending upon the annual visitors for success. Some of the same individuals testified before the legislature regarding the necessity of a hatchery and fish propagation at the lakes, but this may have been of prophylactic rather than therapeutic intent.

There are always some, who, disappointed on a fishing trip, decry the lake or stream as depleted. Such failures are usually due to some more or less temporary cause. Even in well-stocked waters the quality of the fishing varies. There are annual, seasonal, monthly, weekly, daily, and even hourly variations, and sometimes within shorter periods of time. These variations are caused by one or more of innumerable natural conditions or circumstances. To these may be added those produced by artificial causes, which are also too many to be here enumerated. Undoubtedly, in their palmiest days the Rangeley Lakes were not always uniform in respect to the quality of the fishing. At any rate, the earliest available records reveal seasons of poor as well as good fishing. However, the question with which the present-day angler is concerned does not relate to the well-known good and off seasons but to whether or not the fishing has generally and greatly declined, and, if so, what, if any, is the remedy.

In an effort to ascertain, as nearly as possible, the true situation during the time in which the disputes relating to the alleged decrease of trout took place, the writer undertook to compile all of the quantities and sizes of trout and all the expressed opinions afforded by Forest and Stream, American Angler, and Maine Woods, and to compare the published individual views with the synchronous conditions indicated by the figures. In this way it was found that out of 42 years for which definite records were available there were 18 years yielding 100 or more fish each. The highest numerical record was in 1874, followed by 1883 and 1898, in the order named. In the latter year, however, the number did not amount to one-half of the number of 1883. The lowest three years, in the order named, were 1906, 1877, and 1914, and a fluctuating decline was noticeable, particularly marked from 1883, or about the time at which the complaints regarding the deterioration of the fishing began to appear.

Beginning comparisons with 1881, 18 years of the period of 34 years to 1914, inclusive, contained synchronous records and favorable or unfavorable statements. From these data the following table was formed, which aims to give a comparison between the years of synchronous numerical records and the statements of opinion regarding the quality of fishing.

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[a] In 1882 there were 236 trout recorded, 107, or about 45 per cent of which, were caught by two anglers. Again, in 1883, there were 513 trout recorded and eight anglers caught 350, or about 68 per cent of them. If such proportions were anywhere nearly uniform throughout the period covered by this report, it would indicate that the great majority of the fish of standard size were not recorded or else that the fishing was satisfactory to only a few more skillful or more fortunate anglers.

TABLE 9.—COMPARISON OF YEARS OF HIGH AND LOW RECORDS WITH PUBLISHED STATEMENT REGARDING THE QUALITY OF FISHING IN EACH YEAR.

Year.	Record.	Statement.	Year.	Record.	Statement.	Year.	Record.	Statement.
1881	Low	Favorable.	1888	High	Unfavorable.	1899	Low	Favorable.
1882	High	Do.	1889	do	Do.	1900	do	Do.
1883	do	Do.	1894	Low	Do.	1901	do	Do.
1884	do	Do.	1896	do	Favorable.	1905	do	Do.
1885	Low	Do	1897	do	Do.	1907	High	Do.
1887	do	Unfavorable.	1898	High	Do.	1914	do	Unfavorable.

In only 3 out of 18 years did the allegations regarding decline conform to the records, and on one of these there was a statement to the contrary. In four years, also, there were complaints respecting decline when the records were high, and in one of these, while a decline was admitted, the fishing was said to be still good, in another that there were individual good catches, and in another there was a contrastatement to the effect that the fishing had not declined.

In seven years of low records there were statements to the effect that fishing was good and no contrary allegation seems to have been made. In four years, besides those of contradictory statements, there were reports of improved fishing conforming to the records in the respective years.

From the foregoing it would seem that the allegations regarding decline were based largely upon variable individual experiences and seasonal variation. However, since at times competent anglers had grounds for complaint, a relative decline, at least, is indicated. As the term "quality of fishing" is but an expression referring to public angling opinion, a relative decline practically amounts to an actual decline so far as the public opinion is concerned. That there was such a decline is indicated to some extent by the records.

Number and size of trout.—The question of the alleged decrease in the number of trout in the Rangeley Lakes can not be positively settled by figures. The records of the catches of early and recent years afford unsatisfactory comparison for the reason that in former years they were more or less unauthentic and mainly of the large fish. Later, as camps and hotels with increased patronage appeared along the whole chain, more complete records were kept and many of them published in sportsmen's journals. However, these records by no means showed the actual numbers caught, and the fluctuations in the annual records were doubtless, partly at least, due to irregularity of publication, yet the number of fish caught probably affected publication, so that in some degree there is thus afforded an index to the conditions.

Again, in respect to the average size of the fish, it is difficult, from the records, to arrive at a definite conclusion due to the fact that in many of the years only small numbers of large fish were recorded and in others, while the standard of lowest limit was 2 pounds, often those of smaller size were admitted. Some indication is afforded, however, by using the figures pertaining to standard fish only. But as respects both the number and average weights of the fish, there enters the indeterminate factor of increase in number of anglers, for the number of fish might thereby appear to be maintained or increased, and while there might be an actual decrease in average weight of the fish caught, it would not appear if the standard of size were strictly regarded in the records.

Inasmuch as all extraordinarily large fish were probably recorded and more than likely published, the records as concerns numbers of such fish may be fairly depended upon, although the exact weights as recorded, for proverbial reasons, may not always be regarded as authentic. However, the stated records, if not an obvious distortion or consistently reducible to approximate fact, must be accepted.

In 1894, regarding the average weight of Rangeley Lakes trout, Mr. Rich wrote that probably they averaged larger than from any other waters. He stated that he would estimate the average weight caught in the lakes, not including outlying ponds, at a pound, and he further stated that of late years he had kept no record, but did until some 15 years previous, when he had a record of over 6,000 trout, which averaged nearly a pound and a quarter.

In the records of weight, as in those of numbers, the greatest fluctuations occurred prior to 1890, and it is quite evident that the fluctuations were due to irregularity of the weights and numbers of fish recorded and the frequent absence or disregard of standard size. There is a decrease in the number of fish composing the high records, and from about 1900 there is a gradual increase in the numbers composing the low records, due to a tendency to greater regularity. These tendencies are manifested in all three of the classes of fish discussed; that is, all sizes, 2 pounds and over, and 8 pounds and over.

The previously mentioned tendency to fluctuation and the general trend of the whole period from 1873 to 1914, comprising 42 years, may be indicated by arranging the figures for the individual years in 13 groups of six years each, overlapping three years each. In the following table and diagrams this has been done for the three classes of trout discussed. This arrangement shows considerable fluctuation in the number of fish but to some extent levels the average weights in respect to all fish. The largest numbers were recorded in the first, fourth, third, and last periods, in the order named. Therefore, while there was some falling off from the first to the last period, there was a large increase from the fifth period. There was a large increase in average weight from the first period, the largest average being in the second period. In the last some decrease is shown. However, from the fifth period the fluctuations are all in the fractions of a pound over 3 pounds, and the average of the fifth and last is essentially the same, representing the extremes of 30 years.

In the case of fish of 2 pounds and over, the fluctuation is much greater than in the other instance both in number and average weight. A tremendous gain is shown in the last period over the first, the number being the largest of all the periods. The average weight in the last period is the lowest of all the periods, the highest being in the second. The average weight is constantly higher in the first seven periods than in any of the subsequent six periods, representing 24 and 18 years, respectively.

The numbers of fish of 8 pounds and over show a very heavy falling off from the first to the last period, but the fluctuations are great, the twelfth period yielding more fish than the first, and the largest number being in the first period while the smallest is in the tenth. There is not a very wide fluctuation in the average weights, but some decrease is shown from the first to the last period. The heaviest average was in the second period, and the indications are of a decrease in number and average weight of large fish.

The following table and diagrams more clearly show the general trend for the 13 periods designated:

TABLE 10.—CATCHES OF TROUT IN 13 PERIODS OF 6 YEARS EACH, OVERLAPPING 3 YEARS.

Period.	All trout.		2 pounds and over.		8 pounds and over.		Period.	All trout.		2 pounds and over.		8 pounds and over.	
	Number.	Average weight.	Number.	Average weight.	Number.	Average weight.		Number.	Average weight.	Number.	Average weight.	Number.	Average weight.
		Pounds.		*Pounds.*		*Pounds.*			*Pounds.*		*Pounds.*		*Pounds.*
1873–1878...	1,092	1.91	136	5.05	22	9	1894–1899...	589	3.50	292	4.68	19	8.79
1876–1881...	356	4.36	96	5.56	18	9.40	1897–1902...	464	3.64	309	4.53	11	9.11
1879–1884...	945	2.46	261	4.78	27	8.60	1900–1905...	415	3.35	347	3.90	6	8.85
1882–1887...	1,017	2.61	302	5.12	44	9.27	1903–1908...	654	3.48	570	4.09	25	8.73
1885–1890...	521	3.57	280	5.41	47	8.89	1906–1911...	832	3.78	737	4.03	27	8.77
1888–1893...	451	3.26	247	5.09	31	8.58	1909–1914...	885	3.59	781	3.82	10	8.64
1891–1896...	257	3.83	114	5	13	8.55							

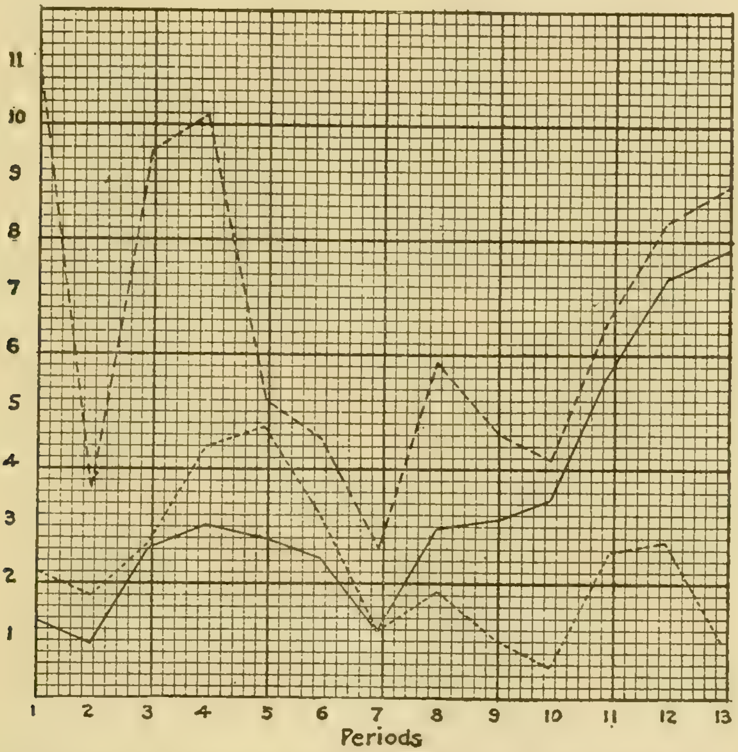

FIG. 19.—Numbers of trout recorded from Rangeley Lakes in 13-year-periods of 6 years each, overlapping 3 years. Broken line, all trout, numbers in hundreds; solid line, 2 pounds and over, numbers in hundreds; dotted line, 8 pounds and over, numbers in units.

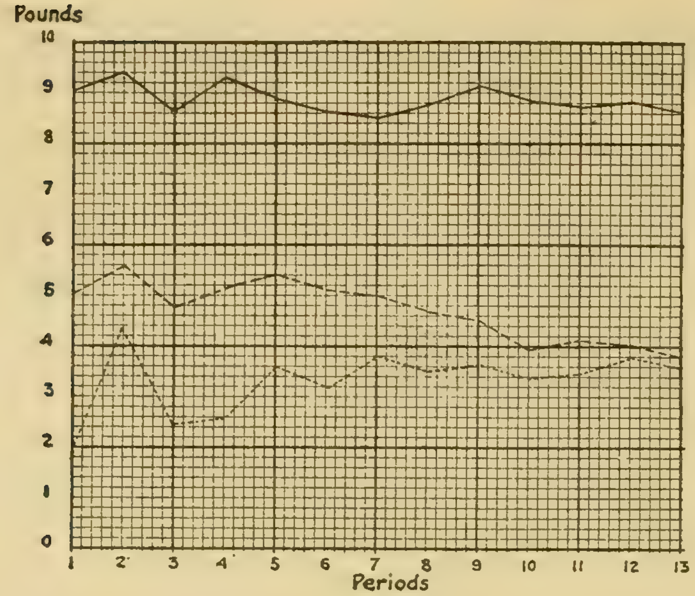

FIG. 20.—Average weight of trout in 13-year-periods of 6 years each, overlapping 3 years. Dotted line, all trout; broken line, 2 pounds and over; solid line, 8 pounds and over.

Records, by lakes.—The assignment of records to the lake in which the fish were caught is impossible in many cases. Many published accounts refer to general regions, and when the report is from some specific locality it is not always possible to ascertain beyond doubt from which lake the fish came. For instance, Mountain View may have reported fish from Mooselucmaguntic Lake or Rangeley Stream without specifying the water. Doubtless the great majority of Upper Dam catches were from below the dam in Mollechunkamunk waters. However, in the present compilation all Mountain View fish have been attributed to Oquossoc and all Upper Dam fish to Mooselucmaguntic. Consequently, Mooselucmaguntic Lake has far larger records than do the Richardson Lakes.

Number and size of trout, by lakes.—In 1887 a correspondent of a sportsmen's paper wrote: "It is a feature of these big trout worth mentioning that the largest have all come from Lake Mooselucmaguntic, the largest of the chain, though there is merely a dam between that lake and Richardson Lake below. The largest fish ever taken in the latter lake would not go over 10 pounds, while the record of the Rangeley Lake, above Mooselucmaguntic, is not much better." Another correspondent in 1896, on the other hand, wrote: "We discovered that Mooselucmaguntic furnished big fish, Rangeley Lake numbers, and Richardson the biggest and finest." However, all the largest fish, from 11 pounds up, were definitely referred to Mooselucmaguntic. The other lakes furnished more or less of the fish from 8 pounds up, but the records compiled for the present report do not throw much light upon the comparative rank of the three lakes, owing to the fact that Mooselucmaguntic doubtless includes many properly belonging to Richardson, because of the uncertainty or impossibility of always ascertaining whether Upper Dam records pertain to the lake above or to the pool below the dam, as previously noted.

From the foregoing figures the inference is that the number of trout greatly decreased until the nineties, when they increased again, but the highest later numerical record, 1914, did not attain to the quantity recorded in the seventies and early eighties. However, there appears to be but little change in the general average weight,[a] and really large fish were taken every year, but not quite so many in any one of the later years as in the earlier years represented by the records. And there is no reason why a trout, if permitted to live, should not attain as large a size as formerly; in fact, in later years, owing to the increased amount of food, its chances are better than in the seventies and eighties.

The foregoing leads to the conclusion that, notwithstanding artificial propagation, the trout of the Rangeley Lakes has decreased to such an extent that there is not an adequate supply, and it may be added that the game-fish supply falls short of the demands, as indicated by the following quotation from the Maine Woods, September 17, 1914, page 1:

> Mountain View House, Rangeley Lake, September 13: Last Monday Hon. Harry B. Austin, chairman of the Maine Fish and Game Commission, met several of the gentlemen at this hotel who are greatly interested in having the best laws to help keep the fishing in this lake. All seem to realize there are not as many fish or as good fishing now as a few years ago and that something more should be done, and that soon, if the June and September fishermen are to continue to come to these lakes. July and August the summer tourists now crowd this region, but they come not to fish but to live out in the open, to tramp through the woods, drive over hills, play tennis and golf, spend their time on the hotel piazza, but are not often fishermen.

Since the foregoing was written, such data for 1915 as was afforded by the Maine Woods became available. For the entire open season the principal hotels and camps reported 345 anglers whose catches were definitely recorded. The total catch of salmon and trout, the individual weight, or the number and aggregate weight of which were given, amounted to 645 in number, of which 549 were salmon and 96 were trout. The average catch of both salmon and trout to each angler for the season was close to two fish (1.86). Each secured an average of only about one and one-half salmon (1.59) and something over one-fourth of a trout (0.28).

As previously indicated, the salmon ranged from 1 to 8½ pounds and averaged about 3½ pounds in weight. The trout had the same range in weight but averaged a little over 4 pounds each (4.09).

These figures need no further comment than is suggested by the statement appearing in the September 20 issue of the Maine Woods to the effect that anglers who fished every day found far fewer fish than when they first came to the lake (Oquossoc) 20 years ago.

TROUT IN THE AFFLUENTS AND CONTIGUOUS WATERS OF RANGELEY LAKES.—All of the streams and ponds, large and small, discharging their waters into the Rangeley Lakes are, or once were, inhabited by trout. In most of them the trout were permanent inhabitants; in a few they appeared only periodically. In some the trout have been depleted by overfishing or by other means, in some the introduction of salmon has had a deleterious effect, and in others the trout fishing still remains satisfactory. The trout of these waters vary in size and appearance according to the character of their habitat.

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[a] The decline in the average weight of fish of 2 pounds and over seems mainly ascribable to the diminution in number of trout of 8 pounds and over.

Some are noted for the beauty or delectability of the fish, and some are distinguished for the sport afforded the fly fisher. The following notes do not include all affluents and are very incomplete in other respects but supply more or less information regarding the places mentioned.

Quimby pond.—This pond has been said to be the only one in Maine in which trout would rise to the fly as soon as the ice was out. The protective restrictions applying to this pond in late years seem to have maintained good fishing, the trout appearing about as plentiful, at least up to a few years ago, as in early times, but the fish average somewhat smaller. Early records included fish of 3 pounds, but later they seldom exceeded 1¼ pounds.

Cupsuptic River.—In the early seventies trout from three-fourths to 1½ pounds were plentiful in this river, but in late years they appear to have diminished in number.

Rangeley Stream.—There are many records for this stream, but most of those of large size are for the fall fishing when the trout are entering the stream for spawning purposes. Early records indicate that in July the fish averaged about 1 pound in weight, but in September many were taken ranging from 2 to 5½ pounds. This stream is now closed to all fishing, excepting in a restricted locality. (See fish and game laws of Maine, 1915–16.)

Kennebago Stream.—The large trout taken from this stream were of the fall run, but there are always more or less trout of fair size therein. They were much larger and more numerous in the old days than in later years. The trout ran about the same as in Rangeley Stream.

Kennebago Lakes.—The water in the lakes is cold spring water, a large number of mountain brooks emptying into them. The lakes are noted for the fly fishing throughout the season. The trout never averaged over one-quarter to one-third of a pound, although some fish weighing a pound are caught and an occasional large fish has been recorded, even up to 5 pounds.

C Pond.—The trout of C Pond are still numerous and always of comparatively small size, averaging less than a pound in weight. An inquiry regarding the color markings of the trout of this pond appeared in Forest and Stream, November 25, 1886: "In addition to their red spots they have about as many black spots as a landlocked salmon. In other respects they are no different from other trout in adjacent waters. What is the reason these trout have black spots?" The black spots referred to were not the natural pigmentation of the fish but parasitic cysts. Many fish occurring in warm waters are affected with this parasite. Just why the C Pond fish are so affected is not evident.

B Pond.—In 1883 J. G. Rich, writing of the trout of this pond, said that they were dark colored, plump shaped, and red spotted, generally red meated, and the sweetest table fish he had ever tasted. He wrote that they were locked in the pond, which was about a mile long with an outlet that ran partly under ground, and that no other fish inhabited the pond. Numerous reports in Forest and Stream from 1889 to 1903, inclusive, contained records of large catches of trout from this pond ranging from 1 to 5¾ pounds in weight and averaging about 1⅔ pounds.

Magalloway River.—Below Aziscohos Falls the principal fishing places in the main river are at the mouths of cold brooks at certain seasons. They have been caught at the falls even in summer, and above the falls the trout are usually at the mouths of streams, excepting when suitable quick water is found above the dead water. The principal fishing is in the tributaries. Fish up to 6 pounds in weight are not infrequently taken now.

Sunday Pond.—In May and June trout have been recorded weighing from 1 to 3½ pounds from this pond.

Diamond Stream.—This stream was once noted for beautiful brook trout up to 1 pound or more in weight.

Diamond Ponds.—These ponds contain fine trout, differing in size in the two ponds according to a report to the effect that in the lower pond trout would not weigh more than three-fourths of a pound while in the upper pond the fish ranged from 2 to 3 pounds.

Parmacheenee Lake.—This lake has long been the most famous of the trout waters of the Magalloway system. No recent records or accounts of this lake are at present available. In 1873 it was stated of Parmacheenee trout that they were not as large as in the other Androscoggin lakes, ranging from 1 to 5 pounds, with rarely one of 7 pounds, which was then the largest known to have been taken.

Cambridge River.—The traditional early abundance of trout in this stream has been referred to in another place. In spring and early summer occasional good catches are now made at certain places, but particularly in a pool a short distance below the forks or the junction of the Dead and Swift Cambridge Streams. Here the water forms a deep pool on the right side of the stream as it makes a bend to the left, and the current is fairly strong even in midsummer. No trout were taken here during the summer of 1906, but there was an abundance of chubs (*S. bullaris*).

Dead Cambridge.—As has already been noted, this stream is the outlet of C Pond In spring and early summer trout can be caught throughout its course at certain places, but especially at the mouth of a small brook called Hastings Brook at the Onion, and the pools up to the sluice. The large pool below the sluice affords excellent trout in early summer and in the fall. During the months of July and August only very small trout are caught there. But above the sluice dam to C Pond the fishing at times is excellent for small trout. In 1905, on July 23, the writer made the following observations on the upper waters of the Dead Cambridge up to 1 or 1½ miles, perhaps, of C Pond. On the way up stream some trout were seen jumping. The sun was occasionally obscured by clouds, giving varying periods of sunshine and shade. Fishing with a fly while the sun was obscured many trout were caught. Having three flies on the leader, they were often taken in twos and threes. When the sun shone the fish would not bite. The largest trout was perhaps one-half pound, and they averaged about one-third of a pound. Blackspot chubs 6 or 7 inches long and common chubs of smaller size were common in the same waters. The temperature of the water about noon at the points where the trout were caught was 60° F. At the sluice it was 72° F. Below the sluice a few very small trout were taken. On August 19 no trout could be found above the sluice, but a few small, slender, dark-colored ones about 6 or 7 inches long were caught on bait and flies below it. On the twentieth, while no trout were found where they were caught in July, about 70 from 6 or 7 to 10 inches long were taken in the pond above the sluice. However, as the gates of the dam were open, the water was very low above the pond. The trout in the pond rose readily notwithstanding the sun was shining brightly. The temperature at the places where the trout were taken in July was 60° F., at the sluice 62° F., and below the dam 62° F.

On September 21 a party of two, in the pool below the sluice, caught a lot of trout, some of which weighed as high as 3 pounds. It was said that they were sluggish, taking bait slowly and a fly not at all. On September 23 the writer, in the pool below the sluice, caught about a dozen trout 7 to 12 inches long. They were nearly or quite in breeding condition and rather dark colored and slab-sided. On the 24th six trout from 6 to 10 inches long were taken on the fly. The smallest was an immature female, the others well-advanced males. Just above the dam one plump but white-meated trout was secured. Notwithstanding the much higher water, no trout could be caught up the stream where they were caught in July.

Swift Cambridge.—This stream is said to have once afforded excellent trout fishing and to be still a good trout stream in the spring and early summer at certain places in its course. On July 11, 1905, the writer caught six trout from 5 to 8½ inches long in the rocky pools below the Andover road bridge.

Sturtevants Brook.—During the summer of 1905 scarcely any water entered the lake from this brook. It was but a trickling rivulet, although the water was cold. On August 9 three trout were caught in shallow water at the mouth. One taken on a fly weighed 2½ pounds. Two others of one-half and 1 pound, respectively, were taken on worm bait. Again, on August 12, one of one-half pound was caught here on worm bait. It was reported, however, that Mr. Dutton had made some good catches on a fly at this place.

Not far from this brook is the famous deep hole of Umbagog Lake, off the mouth of Sunday Cove. In about 53 feet of water, on August 12, one trout weighing 1 pound was caught on worm bait, and on August 17 six trout from about 10 to 12 inches in length were taken in a gill net set in the same place. With the trout, six salmon and one whitefish were caught. One of the salmon's stomach contained three smelts.

Molnichwock Pond.—This pond once afforded comparatively large trout. Fishing through the ice in the latter part of the winter of 1883, the writer caught two trout of about 2 pounds each, and on August 18, 1905, he caught here six trout, three of which were 8, 8¼, and 8¼ (one being a well-advanced female), and three were 12½, 13, and 13 inches long, respectively. All of the latter were well-advanced females. The 12½-inch fish contained in its stomach a chub minnow (*Couesius plumbeus*) 4¼ inches long. The temperature of the outlet of the pond was 56° F., at mouth of inlet 62° F., surface out in the pond 70° F., and the bottom in 10 feet of water at the east end of the pond 62° F.

Molnichwock Brook.—At the meadows this brook has for years furnished most excellent brook-trout fishing. If it were not almost impossible to fish the brook in the wooded or alder portion, it would undoubtedly have been exhausted long ago. The writer, on several occasions in 1905, fished this portion of the brook with the following results: July 16, 51 trout, averaging about 8 inches in length, one of three-fourths of a pound; July 27, 55 trout, 7 to 10 inches in length; August 6, 57 trout, 6 to 11 inches long. Most of these were secured in the alder tangle below the meadow. On August 23 only 3 trout were caught, and they were small, dark-colored individuals, 5 to 6 inches in length.

SMELT (*Osmerus mordax*).

The smelt is most widely known as a marine fish which ascends fresh water to spawn, but there are many coastwise and some rather remote fresh waters that contain smelts as permanent residents. They are the so-called landlocked forms. In some of these fresh waters the smelt attains maturity and breeds when only 1½ or 2 inches in length and never reaches a greater length than 3 inches. In other fresh waters the fish grows to a length of 15 inches or more and a weight of at least a pound. There are also many lakes or ponds where intermediate sizes as adult fish occur, and some where there seem to be two distinct adult sizes. Whether these are distinct species or not has not been determined. Many years ago Cope described two Maine fresh-water smelts as distinct species—one, *Osmerus abbottii*, found in Cobosseecontee Lake, the other in Wilton Pond. The latter, from its translucence, was named *Osmerus spectrum*. No other fresh-water smelts have received specific names, and owing to the uncertainty regarding which of these two names, if either, should be used for the Rangeley smelt, the name of the marine form is employed.

According to the statement of a resident of Rangeley, the first plant of smelt was in 1891, but the first and only record for the introduction of smelts into Rangeley Lakes appears in the State fish commissioners report for 1895. In answer to an inquiry by the writer, L. T. Carleton, then chairman of the commissioners of inland fisheries and game, wrote:

> Replying to yours of recent date regarding the origin of smelts in Rangeley Lakes, I beg to say that my former associate, Mr. Stanley, writes me as follows: "The first smelts were put in Rangeley Lake from Weld Pond. They were all small not more than 3 inches long when fully grown. Later they were introduced into Mooselucmaguntic from Swan Lake near Belfast. They were of a variety that grew from 3 to 10 inches in length. None of the large variety were put in Rangeley, the upper lake. The eggs were gathered promiscuously from streams where smelts spawned. They appeared in considerable numbers within four years. They are now plenty in all the lakes from Rangeley down." (March 13, 1907.)

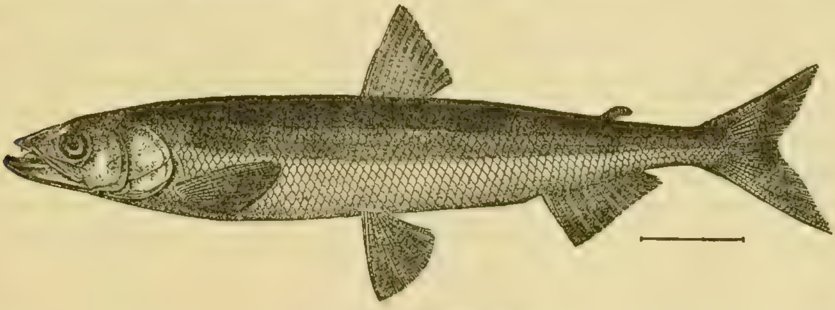

FIG. 21.—Smelt (*Osmerus mordax*).

The smelt's food varies somewhat in character according to the size of the fish. Large smelts have been found to feed to a great extent upon smaller fishes, particularly their own young. Small smelts subsist largely upon entomostracans.

The breeding time in some places begins early in March, even before the ice is out of the lake. At other places it occurs in April and in May. At the spawning time the smelt usually ascends brooks, although in some lakes shoal water along shore is the spawning resort. In the Rangeley Lakes the smelts ascend brooks, usually soon after the lakes are free from ice. In 1904 the Maine Woods of May 4 stated that on Saturday the smelts were reported running up Dodge Stream "in bushels," and in the same paper, May 17, 1907, the following appeared:

> Smelts are reported to be very much in evidence in Rangeley Stream between Rangeley Lake and Mooselucmaguntic Lake. They have been seen in great numbers near the Oquossoc Angling Association Clubhouse at Indian Rock. Hundreds of them have been caught this spring.

The issue of that paper of May 31 of the same year stated that "One man dipped 4 bushels of smelts, and they were fine eating." The same paper of April 28, 1910, noted: "Smelts have begun to run early this year. A large quantity was taken from Kennebago Stream last week and more this. The smelts are of good size and fine quality, and the quantity is said to be unlimited."

The duration of the spawning run varies in different localities, sometimes continuing a month or more or lasting only a week or two. The Maine Woods, May 12, 1905, stated that the run of Rangeley smelts began as soon as the ice was out and lasted a week or 10 days. The males first appeared on the spawning beds, later both sexes. The eggs are small, numerous, and viscid, becoming attached to stones, stocks, plants, etc. It is recorded that a smelt weighing 2 ounces yielded from 46,000 to 50,000, but the eggs of a smelt 4⅝ inches long, counted by the writer, numbered only 5,893.

The smelts of Rangeley Lakes appear to attain only a small size. Thirty-six specimens collected in Oquossoc Lake about the 10th of May, 1904, ranged in total length from $2\frac{14}{16}$ to $3\frac{8}{16}$ inches, of which 24 varied only $\frac{2}{16}$ of an inch ($3\frac{2}{16}$ to $3\frac{4}{16}$).

Throughout the season, especially after a "blow", smelts are often found washed up on the beaches, but particularly during or immediately after the spawning time they are found in large numbers, dead and dying, at the surface or washed up on the shore. The cause of this mortality has not been ascertained. Only a few years after the introduction of the smelts into Rangeley Lakes it was reported that about the spawning time they were washed up in windrows and by their decay produced an almost intolerable stench. In the year following the recorded introduction Forest and Stream, June 13 (1896) stated that in the vicinity of Rangeley Lake there was a good deal of concern manifested among guides and others at finding a great many dead smelts along the shore of that lake. The suggestion was that some disease had broken out among them. The same paper, May 27, 1899, stated that the dead and dying smelts had been unusually numerous. The Maine Woods, May 12, 1905, reported "lots of dead floating on the surface."

There are those who aver that the presence of smelts in any lake destroys fly fishing and is generally very injurious to bait fishing. Forest and Stream, June 12, 1897, contained the following from the pen of a Rangeley Lakes correspondent:

> Perhaps the poor fishing in Mooselucmaguntic and Richardson Lakes is due to the smelts, which have appeared in great numbers for the first time this spring. Perfectly reliable guides say that the water has been alive with these smelts. Later they have died by the thousands and have been seen floating on the surface dead or dying. Every trout caught has been simply gorged with these smelts. This I saw myself in the case of trout being dressed. The question of these smelts ever having been introduced into the Rangeley waters is a very grave one. Guides and sportsmen who have watched and fished these waters for years are in doubt, to say the very least, and some of them are mad all through. I heard it freely expressed that the most wonderful brook-trout fishing of the world—at the Rangeleys—has been ruined by putting in smelts for landlocked-salmon food—landlocked salmon that can, at the vey best, never equal what the brook trout have been to these waters. As for myself, I have no opinion at present. The smelts in the maw of the trout I have seen and have seen the dead smelts on the water. I have also seen the remarkably fattened condition of the trout as compared with the fish of the past 20 years, with which I have been familiar, catching and examining them each year in greater or less numbers. Would it not have been much better for the State of Maine, through its fish commissioners, to have hatched a great many brook trout each year and put them into Rangeley waters, thus keeping up the supply of a fish altogether satisfactory, rather than to have been dabbling with fish not formerly found there? Who does not remember the introduction of the English sparrow? Who will claim that natural conditions as to fish and game are not the best?

The same paper of May 20, 1899, reported:

> The fishing has not been up to former seasons, since the water is the highest ever known, and in both Richardson and Mooselucmaguntic Lakes are millions of smelts, many of them dead from spawning. The trout are "just gorging" on these smelts and will not take artificial flies or other bait till the smelts are gone. Still a few trout are taken.

In the issue of May 27 of the same year the same paper stated that the last reports showed that the smelts were fast disappearing, and there was little doubt but what fishing would be better very soon. The smelts had been remarkably numerous in all the trout and salmon waters of Maine and New Hampshire, with more than the usual number of dead and dying on the surface. Later these little fish disappeared, no one knows whither, and the trout and salmon that had been feasting on them were forced to seek other food.

The same paper of August 30, 1902, contained an article by "Special," entitled "Rangeley trout and the smelts," as follows:

> Boston, August 23: Mr. Henry W. Clarke, of Boston, a veteran angler in the Rangeley waters, has just returned from a stay of seven weeks at the Mountain View, foot of Rangeley Lake. This was Mr. Clarke's twenty-eighth successive annual trip to those waters, and his opinions naturally carry a good deal of weight on angling subjects. He says that of all the seasons he has ever spent there the past has shown the poorest fishing. His idea is that the poor fishing is largely due to the putting of smelts into the Rangeleys. He says that the smelts are in deep water the most of the season, only going up into the streams to spawn in the spring. The trout have found them better eating than the old-time minnows, for which the Rangeleys have always been noted, and, like the salmon, they follow the smelts into deep water. Mr. Clarke says that he caught one trout, hardly 3 pounds' weight, which had in its throat and maw 53 smelts. He adds: "It must have taken my hook out of idle curiosity. There could have been no other reason for its biting." Mr. Clarke regards the stocking of the Rangeleys with smelts as a dangerous experiment at the best. He believes that the trout fishing has been greatly injured thereby. Mr. C. P. Stevens, another veteran angler at the Rangeleys, has the same idea. He says never has the trout fishing been so poor in the vicinity of his cottage, in the narrows, Richardson Lake. It is the opinion of other "old timers" at the Rangeleys that the big trout of that region are done for, and it is certain that not half the usual number have been caught the past season, while the catch of salmon has been greater.

The smelt was introduced into these lakes, primarily, as food for salmon, for which purpose these small smelts are particularly suitable, but undoubtedly the trout was also greatly benefited in that way, as indicated by the following notes: Forest and Stream of May 14, 1898, stated that a trout of 1¾ pounds' weight, upon being unhooked, disgorged 13 smelts, and a communication to the Maine Woods of May 31, 1907, stated that a 3-pound trout caught in Mooselucmaguntic Lake had eaten 37 whole smelts, and it was not known how many more. This was said to be a true smelt story, "for," the correspondent said, "I put them on the wharf and the boys counted them."

That the large size attained by trout is due to plentiful food can not be denied, and it is a well-known fact that where trout are practically restricted to insect diet they do not attain a large size. As has been previously stated, the large size of Rangeley trout was ascribed to the abundance of smaller fishes. The change brought about by the introduction of smelts was only one of greater amount of fish food and could in no way affect the manner of feeding. The trout is just as prone to vary its diet by resorting to insect food while smelts are abundant as it is when any other fish, cyprinids, or bluebacks furnish the major part of its food supply. Furthermore, experience on other waters where smelts abound have shown that the trout as readily takes the fly there as where there are no smelts. When the smelts are running, it is not the usual fly time. When through with their spawning, the smelts go into deeper water. The trout do not seek those waters until the approach of warm weather, when fly fishing ceases, except on some cool pond or at the mouths of cool streams or in the streams themselves.

It may be affirmed that the only fish that has been wisely introduced into Rangeley Lakes is the smelt. It has directly and indirectly been the savior of the trout by affording the trout requisite food and detracting to some extent the attention of the salmon from trout by furnishing sufficient natural food.

PICKEREL (*Esox reticulatus*).

This species is the only representative of the pike family in New England waters except in the St. Lawrence drainage or where it has been introduced. It is the only species in Maine. Its geographical range is stated to be from Maine to Florida and Louisiana; common everywhere east and south of the Allegheny Mountains. Originally, or perhaps it should be said aboriginally, the pickerel had a very restricted natural geographical distribution in the State. Since early days it has from time to time been transplanted to other waters, and from such sources it has made its way into still other waters, so that at the present time there is scarcely a congenial pickerel abode in the State that is not inhabited by it.

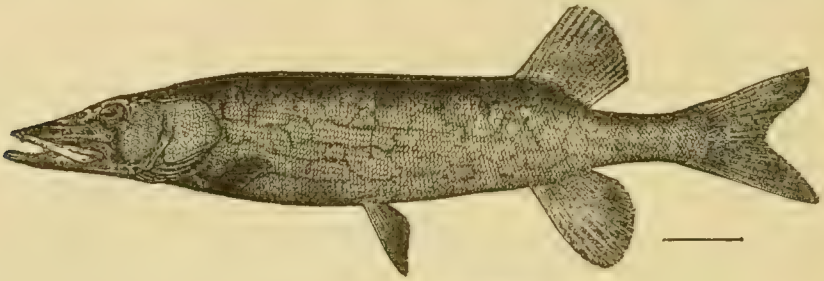

FIG. 22.—Pickerel (*Esox reticulatus*).

Of the Rangeley chain of lakes, Umbagog is the only one inhabited by the fish, and there it was not indigenous. The precise date, manner, and reason of its introduction into Umbagog Lake are uncertain. But there is a sort of tradition among the older inhabitants of the vicinity of the lake that early in the sixties or some time before some inhabitants of the lake shore, having been prosecuted for violating the trout law, out of revenge placed pickerel in Umbagog Lake, where they rapidly waxed great in numbers and size. It is now apparently restricted to Umbagog Lake, being unable to get beyond Middle Dam. It has made its way up the Magalloway River, it is said, as far as Aziscohos Falls, beyond which it can not go of its own accord.

The pickerel sometimes attains a weight of 7 or 8 pounds, but as usually met with 3 or 4 pound fish are considered large ones. There seem to be no records of the sizes attained in Umbagog, but the writer remembers from personal experience that 3-pound fish were very common there in 1883, and the complaint then was that pickerel were not as large as they once were. The largest obtained in 1905 weighed about 4 pounds, measuring 23 inches in length. Other adult fish caught measured 12, 17, 18, 20½, and 20¾ inches, the majority being not much over a foot in length. (See Table X, p. 594.) Young pickerel ranged from 2 to 10 inches in length. The smallest observed were collected on July 15, measuring 2, 2½, and 2¾ inches in total length. Young were fairly common throughout the season, but there was a complaint that it was a poor season owing to the high water and hot weather. It was a fact that no large fish could be caught on a hook until toward the last of August and first of September. Even then the scarcity and small size of the fish were quite noticeable and in strong contrast to some 20 years previous.

The pickerel spawns in spring in shallow water among water plants, brush, or rocks. Its eggs are in long gelatinous masses or strings, and the newly hatched fish are so tiny as to be almost or quite invisible in the water. But they grow comparatively rapidly, yet owing to the small size of the fry they do not appear to reach a length of much over 2 or 3 inches and some of them not even that much in the first season. The pickerel deposits a good many eggs. If it did not it would soon succumb to its numerous enemies to which the young are exposed in shallow water. About its only protection is its quickness of movement and its color when among the water plants.

When feeding, the adult pickerel will eat almost any living thing that it can secure, and will secure anything that moves in its immediate vicinity. It, as a rule, lies under the edges of patches of lily pads or other aquatic vegetation, alongside of a submerged tree or log or a bowlder, whence it darts forth and grabs its prey. Its food consists largely of other fishes, frogs, and such other aquatic animals as it may be able to obtain. Very small young subsist upon small insects, entomostracans, and insect larvæ. As they increase they take larger objects, often those that are greatly disproportionate to their own size. Observations upon the food of pickerel in 1905 revealed that young up to about 4 inches long were feeding upon entomostracans and insect larvæ. Of eight young from 4¼ to 6⅜ inches long caught at the same time and in the same place, six contained fish and four of these were young pickerel. Of another lot, a 4¼-inch fish had another ickerel 3 inches long in its intestinal tract; one, 5⅜ inches long contained a pickerel 3 inches long; another, 5⅞ inches in length had, besides other things, one pickerel $2\frac{1}{16}$ inches long; still another, 7⅝ inches in length contained two small minnows; and one 6⅜ inches long had in its stomach one pickerel 3 inches long and one shiner (*Notemigonus*) 2½ inches long. On another occasion each of two, 7½ and 12 inches long, contained a 1½-inch hornpout and one of them the head of a small chub besides. Each of five fish taken off B Point in a gill net contained partly digested suckers. Other instances were: One, 7½-inch pickerel had the head of a small chub; a 9½-inch fish contained a $2\frac{5}{16}$ inch pickerel; one, about 20½ inches long, contained the bones of a small fish.

The pickerel is reputed to be one of the most voracious of fishes, but it is no more so than the majority of so-called predacious fishes. Like other fishes, it abstains from food for considerable periods, and it does not always feed at any time of day. Indeed, it is rarely that it feeds during the interval between morning and evening. It is a recognized fact that during the summer months, excepting on cloudy or rainy days, the early morning and evening are the best times for pickerel fishing. The pickerel thrives best in shallow, comparatively warm waters, where there are plenty of water plants and the plenteous food incident to such places. In winter it often seeks somewhat deeper waters, and the large fish frequently affect bold rocky shores. The adult pickerel is not much of a wanderer and, as a rule, lies in wait rather than searches for its prey. Usually it is the younger fish that make their way upstreams into other waters. It does not thrive in deep, cold lakes.

Many regard the pickerel as a worthy game fish, and as a food fish it is held in esteem by many and disliked by a few.

Some of the inhabitants of Umbagog's shores relate that their fathers remembered when trout abounded in Umbagog Lake, and that if vengeance on the trout as revenge for legal wrongs was the motive that placed the pickerel in the lake the object of its introduction was woefully successful, for the trout practically disappeared and the pickerel became abundant. J. G. Rich, in American Angler, April 14, 1883, wrote:

> For the last 12 years the trout have been fast diminishing, until now only occasionally a large one is to be got, and no small ones seem to be in the lake. I think in 1850 Umbagog was as well filled with trout as any other lake. It certainly yielded great sport to all who came from cities and elsewhere to fish. The last trout I caught from this lake was at Sturtevants Brook, two years ago, and it weighed 3 pounds. At the same time and place I took a large string of pickerel.

Thus, it is with Umbagog Lake as with most other lakes and ponds that once contained trout and now are pickerel waters, it is claimed that the pickerel have destroyed the trout.

The same writer in the same paper of February 6, 1886, said: "Two men went from Bethel last week to Umbagog Lake—the lower or most southern lake of the Rangeleys—25 miles distant, and caught 100 pounds of pickerel in two days."

Umbagog Lake, as has already been stated, is not ideally suited to trout. It is very generally shoal and consequently much warmer during the summer months than waters in which trout thrive best. There are only two restricted localities, or deep holes, to which trout can resort in the warm season in this lake. These deep holes have been known for many years to some of the inhabitants of the region, who availed themselves of the advantage afforded by this knowledge. There has been no time since pickerel were introduced that some trout could not be obtained from these holes, but owing to their restricted limits it has always been comparatively easy to fish them out, and this has been done repeatedly.

The usual habitat of pickerel is widely different from that of trout, although there are individual exceptions. Other fishes, especially suckers and cyprinids, find proper conditions in the same localities that are the favorite abode of pickerel. Notwithstanding this fact and that these fishes are comparatively easy prey, their numbers do not seem to have been diminished. As previously mentioned, there are still some trout in Umbagog Lake. Salmon and whitefish have increased in numbers. Pickerel are fully as destructive to these fishes as to trout. The natural inference, then, is that pickerel have not been the cause of the scarcity of trout in the lake.

In 1882 C. T. Richardson, under date of July 27, in Forest and Stream of August 5, stated that two men caught in Umbagog Lake, in less than 6 hours, 51 trout weighing 103 pounds.

On the other hand, there is a general complaint that pickerel have, in late years, become comparatively scarce and do not attain the general large size that they once did. Constant increase of maintenance of numbers is possible only when adverse conditions are less or exactly equal to the favorable conditions. Maximum size is attained by any fish only when it is provided with sufficient food, room in which to grow, and meets no check in its career. In other words, when favorable conditions preponderate over the unfavorable. Numbers are reduced by subtraction. The process may be through starvation, disease, natural enemies, etc. There is no evidence of there ever having been a scarcity of food. There are only two records of any undue mortality from unknown causes which might have been disease. One is a communication from J. G. Rich to the American Angler, January 25, 1884, in which, under the heading of "Dead Pickerel in Lake Umbagog," he wrote:

> In the spring of 1880, soon after the ice went out, there were floating on the surface of the water and on the shores dead pickerel in immense numbers and of various sizes, from less than a pound weight to 5 or 6 pounds, more, perhaps, of the large ones. This occurred more in the southern part of the lake, where the water is shallow and the shores grassy, than in the northern and deeper parts, although dead fish were over the whole surface more or less. Other fish exist in the lake besides pickerel, such as chubs and suckers and some trout, yet no other fish were observed to be floating. If I mistake not, the same year dead fish of an unknown kind were seen floating on the Atlantic Ocean in large schools, to explain which various theories were put forth by learned naturalists, but no certain reason given. Some persons here think the mortality among the pickerel was caused by their getting into shallow water and the freezing of the ice to the bottom or a sudden fall of the lake dropping the ice on to them. But if this were the case why did other fish escape? Certainly the pickerel are as active, if not more so, than any other and could fall as rapidly back into deep water and safety. Who knows the cause of this wholesale destruction?

The other record was a statement by C. J. Craig, to the effect that during the last of May and first of June, 1912, the water of Umbagog Lake was higher than ever before known. Dead pickerel were around the shores in large numbers all about the lake. Most of them were good-sized fish. Nothing but smelt was found in their stomachs. Bait was secured by opening pickerel.

As has already been stated, the writer, in 1883, found pickerel abundant and many of fairly large size in Umbagog Lake; therefore, the mortality mentioned by Mr. Rich did not exterminate the pickerel or more than temporarily greatly reduce their numbers.

Many natural enemies can be enumerated, such as birds, frogs, other fishes, and even the pickerel itself. Among the birds, the merganser, grebe, loon, kingfisher, and heron are the most destructive. But the birds have not been numerous enough in many years to seriously reduce the numbers of pickerel.

Bullfrogs are consumers of young pickerel, but their numbers are not sufficient to make any very appreciable decrease in numbers of the fish. That other fish do eat pickerel is well known, as the following incident indicates: On August 12, 1905, in the large "logan" at the entrance to the Androscoggin River, some fish were seen pursuing other smaller fish, which went skipping over the surface of the water. The larger fish, which were at first supposed to be pickerel chasing cyprinids, proved to be chubs after young pickerel. Several from one-third to one-half of a pound in weight were caught on a small casting spoon and found to contain young pickerel from 2½ to 3 inches in length. That the pickerel is somewhat of a cannibal has been previously shown.

But all of the enemies were far more numerous at the time the pickerel were increasing in numbers than they have been in recent years; therefore, there must be some more potent cause of decrease. The reduced size of those now caught and observed can not be due to the above-mentioned enemies, as they prey upon the smaller individuals and the larger ones would be left to grow still bigger. The cause, then, must be something that affects the larger fish.

There is one assignable cause that applies to both the disappearance of trout and reduction in numbers and size of the pickerel, and that is man. He seeks the larger fish, he seeks numbers, and often at a time when the largest numbers of large fish can be obtained, that is, during the winter by fishing through the ice, when pickerel are hungry and its natural food has concealed itself in the mud or amongst the water plants and moves but little or not at all. Ice fishing is one of the most potent causes of the depletion of northern lakes, especially small lakes like Umbagog, of their food fishes, and there can be little doubt that by this means, augmented by annual plug fishing in their limited summer resorts, the trout of Umbagog Lake have been diminished so greatly in numbers.

MILLER'S THUMB (*Cottus gracilis*).

The miller's thumb is a fresh-water sculpin. The only vernacular names that seem to be applied to it in Maine are brook cusk and rock cusk. It is sometimes mistaken for young cusk, *Lota maculosa*, which does not occur in the Rangeley Lakes. This species is apparently the only one in New England fresh waters, disregarding, possibly, the Lake Champlain and St. Lawrence drainage, but it is very common almost everywhere, especially in northern waters. In some places, however, it has become greatly reduced in numbers by other fishes feeding upon it. On the other hand, it is very destructive to the eggs of such species as spawn where it occurs. The only record of its occurrence in the Rangeley Lakes is that of specimens in the museum of the Boston Society of Natural History, collected by Prof. F. W. Putnam many years ago, and the statement of Mr. Haines, of Rangeley, that it is often found in trout stomachs.

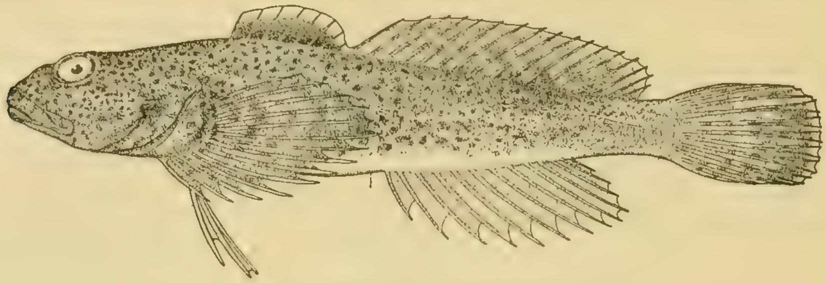

FIG. 23.—Miller's thumb (*Cottus gracilis*).

It attains at least 4½ inches in length. Large individuals, up to 4 inches long, however, occur in the Androscoggin River, and the writer has examined specimens from Bear River in North Newry. (See Table XI, p. 594.)

The coloration of the different individuals varied somewhat, but in general the body was gray with reddish tinge above, speckled with darker gray, and with traces of five dusky crossbars, of which only the one under the posterior part of dorsal extends fully across the body; spinous dorsal margined with reddish and broad dusky strip through the middle; soft dorsal, pectoral, and caudal finely barred with black.

SUMMARY.

Immediately before the advent of white men the conditions of the lakes were much different from those of the present time. They had a smaller area, lower level, and much less volume. Their intercommunications were unrestricted except by natural obstructions, which were not barriers to the passage of the larger fishes. Each lake differed somewhat from the others in physical characteristics and consequently in some respects in biological conditions. Each had its natural limit to the amount of life it could sustain and its approximate balance of life, in which area and capacity were controlling factors. But all of these were subsequently altered.

The earliest and most decided modifications of area and capacity were produced by dams, which were not only restrictive in effect upon both the limit and approximate equilibrium of life but, by more or less sudden interference with the habits of fishes, otherwise injurious. These modifications were not constant in their action in any one direction but interrupted and periodic, and their effects were consequently variant. Some of the effects, too, were slow and gradual in development, others sudden and more or less cataclysmic. By the erection of the most recent dams constant higher stages of water than formerly have been produced, accompanied by some advantageous conditions, such as that of enlarged physical and biological capacity. But these were reduced in value by the unsettled conditions resulting from the operations of the dams.

High stages of water are stated to afford new feeding grounds, but this signifies only a change of locality. Fish were enabled to ascend farther up some brooks and even onto low overflowed meadows, but as these stored waters were bound to be drawn upon sooner or later the possible effect of that operation is obvious. The high water facilitates the ascent of streams in the breeding season, but it also covers the former shoals with an excess of water, and other places of suitable depth must be sought.

The inevitable lowering of the water has a much greater reverse effect along the same lines. During the periods of varying length that the dams were closed fish that served as food for trout were prevented from going down stream, but their predilection for such places, causing them to congregate in the still water just above the dam, resulted in a wholesale outflow when the gates were opened. As an illustration, it may be appropriate to mention that several species that otherwise would not have been collected or recorded from the Rangeley region were secured by first opening and then closing the sluice gates in the Dead Cambridge River. Hundreds of minnows of several species and some trout were found in pockets amongst the rocks and even scattered through the bushes of the low-lying banks close to the edge of the stream.

This sudden drawing off of the water also affects seriously the fishes that have entered the overflowed meadows and small brooks, often leaving them stranded to slowly perish as the pools left by receding water become heated or evaporated.

All of these things and more have been and still are operative at the Rangeley Lakes. If by chance the fish have time to become accustomed to temporary prevailing conditions, the sudden changes can be only to their general disadvantage and must necessarily cause a constant unsettled and unstable condition, which can but react unfavorably upon a perpetuity of the fish supply.

Oquossoc Lake is the uppermost and smallest of the chain and is a faunal recipient of only a limited amount of tributary water, while it may contribute to the whole chain below. It may, therefore, be expected that it would be the first to show any disturbance of the general faunal balance. Mooselucmaguntic, including Cupsuptic Lake, is the largest and most diversified of the chain. It not only receives from Oquossoc and from the Kennebago and Cupsuptic systems but from other smaller contributories. Its principal faunal donations are to the lower waters. It should be the slowest to react to disturbing influences. Molechunkamunk and Wellekennebacook, although smaller than Mooselucmaguntic, probably compensate for their loss through the outlet by the benefit they receive from the upper waters. Therefore, if exact data were available it would, perhaps, show little difference from Mooselucmaguntic save in quantity and would be no more appreciably affected by a general disturbance of the whole chain.

Umbagog has a greater area than Oquossoc or the last two lakes mentioned, but it is generally much shallower and is otherwise of a very different character. Its faunal contributive resources are much more extensive than all of the other lakes together. But owing to the widely different prevailing conditions, some forms of life continue to exist only through tolerance, and are, therefore, in unstable equilibrium and subject to serious disturbances from slight causes. Some of the forms could not at all times tolerate the general conditions were there not ameliorating factors. The ameliorating conditions being restricted, these tolerant forms are necessarily limited in number and are, therefore, more easily exterminated. The stock of such forms depends largely upon renewals from contributive waters.

The deficient general data respecting the distribution of the fishes in the Rangeley Lakes prevent reaching very definite conclusions regarding their source and manner of origin, as well as their ecological importance, past and present, but the few known facts are suggestive. A knowledge of the source and manner of the origin of the fish fauna is not particularly pertinent to a discussion of present-day conditions, but it may be briefly stated that probably the majority of the species gained access during a period of a lower level of the land and relatively higher stages of water and are mostly of northern derivation, perhaps by way of what is now the Kennebec Basin. The fish fauna of the Rangeley Lakes shows a contributory but not much if any recipient relationship to the Androscoggin River, from the fact that most of the Rangeley Lakes species are those of common distribution and are found in the river, while others of common distribution occurring in the river are not found in the lakes.

Of 39 species of fresh-water fishes recorded from Maine, New Hampshire, and Vermont, 35 of which are known from Maine, only 13, or just one-third, were apparently indigenous to the Rangeley Lakes Basin above the Androscoggin River. One of these was for a long time considered as peculiar to the Rangeley Lakes and restricted to two of them. Twenty-one of the Maine fishes are very common in certain regions of the State, and 13 are of general distribution throughout the State. The fauna was thus to some extent unique but of concentrated quality, as it were. There were only two species of food fishes and only one of these a game fish. All but one of the remainder of the fishes that were at all common served as food for this one game fish, some of them as a continuous supply, the rest at least as a seasonal or temporary resource. Thus, one game fish levied more or less upon 11 different species. Some of these reciprocated or retaliated to some extent by attacking the game fish at some stage of its existence, but their principal food consisted of smaller animal life, for which all species competed.

The biological oscillations produced by modifications of the physical conditions have been amplified by the introduction of competitive and destructive factors, resulting in changes in the fauna. Among the fishes, instead of the 12 or 13 original species, there are now 16 or 17, at least one, or perhaps two, of the original forms having been replaced by new ones. There is, perhaps, an approach to a readjusted balance, but it apparently is unsteady and dependent upon a continuous readjustment by fish culture. The salmon has become the dominant species and, therefore, the most extensive and intensive influence. It has spread throughout the chain of lakes, even into the Androscoggin River. In Umbagog Lake, however, it probably exists to a limited extent only through the favor of the two deep holes. The salmon is the most powerful competitor in the food supply of the trout, as their all-of-the-year habitats are identical and they subsist upon the same kind of food, and the salmon, possibly, to some extent upon the trout. The trout supply evidently requires the aid and advantage of artificial propagation.

The pickerel has been restricted in its effects to Umbagog Lake, where it has never suffered from the lack of sufficient food and where it has not been to any extent dependent upon the trout. On the whole, it has found a congenial habitat in the lake, but has been subject to occasional mysterious mortal epidemics. A possible, if not to say probable, explanation may be found in the existing conditions partly produced by artificial modifications of the biological conditions. The lake being long and narrow, with its longest axis lying north and south and out of the direction of the prevailing winds at the time, receives a comparatively small amount of oxygenation from wind and wave action. The death of a great quantity of plant and plankton organisms, both resident and inflowing, might result in a greater amount of decomposition accompanied by an excessive amount of carbon dioxide. Furthermore a large amount of plankton is usually associated with high carbon-dioxide and low oxygen contents. An obstructed outlet would produce an increased amount of plankton, and an obstructed inlet would, perhaps, produce a temporary partial stagnation. Carbon dioxide is very toxic to fishes, but some fishes are less affected by it than others. The carbon dioxide content is usually highest in April and June. The early epidemic previously mentioned apparently occurred soon after the lake was free from ice, probably some time in May. The epidemic of 1912 occurred in the last of May and first of June, when, it is stated, the dams of the outlet and inlet had been for some time closed for storage purposes. While the cold of winter and early spring would retard decomposition, the surface ice would, on the other hand, prevent oxygenation from winds and wave action. An inspection of the map of Umbagog Lake will perhaps show that its general shape and the location of the main inlet and the outlet would support this idea.

Smelts have increased in number and have spread throughout the chain, even occurring in Umbagog Lake. They are of undoubted value as food for the salmon and trout, in which they have supplanted the blueback trout, and in that direction are of no little importance to the inhabitants of the region, as indicated by the following quotation from Maine Woods, May 1, 1913:

> The smelts began running in Kennebago Stream last Thursday night (Apr. 24), and much sport among the residents is being enjoyed. "Going smelting to-night?" is the form of greeting heard from young and old, and if you don't reply "You bet I am," you are no sport, for when the smelts start up Kennebago Stream the whole town turns out to meet them, for they are the first fish of the season, and when salt cod and herring have been the fish course all winter they certainly do taste good. From Indian Rock to a goodly distance upstream one can see the glint of lantern and small fires, where groups of men and boys are gathered, dipping smelts from the stream to pails, boxes, and grain sacks.

CONCLUSIONS AND SUGGESTIONS.

The artificial modifications of the Rangeley Lakes waters have in some ways been beneficial, in others directly and indirectly detrimental to the fishes of these lakes. Early excessive and unseasonable fishing caused the necessity for legislative and fish-cultural action. The necessity was augmented by the annually increasing number of anglers. The trout supply was not greatly increased by fish culture, owing to the fact that the Rangeley trout were for many years the source of supply for other waters.

Partly to meet the demands of the greater influx of anglers each year, the landlocked salmon was introduced. In furnishing the anglers with more game fish the introduction of the salmon was a success, but its introduction resulted in the extinction of the blueback. The blueback, however, was of no direct importance to the angler; but the fact of its disappearance from this evident cause suggests that the cause of the continued decrease of trout, for some years at least, may have been due to the same fish. The salmon now greatly preponderate over the trout, notwithstanding the extensive planting of trout.

Any maintenance or increase in numbers of trout as shown by the records of catches is only apparent and due to the greater number of anglers fishing there. It is undoubtedly true that the trout are decreasing in numbers and fewer large ones are caught than formerly. To keep up the trout supply, even approximately, many more trout need be planted annually. It is doubtful, however, even with the salmon eliminated, if a sufficient number of trout could be supplied to adequately meet the present requirements of the large number of anglers. The salmon is more responsive to fish culture and conservation, and to the majority of anglers, if not preferable to the trout, furnishes a very satisfactory substitute. It is, however, a matter of regret to many familiar with the one-time glory of the Rangeley Lakes as trout waters that the salmon was ever introduced. But the evil, if it were an evil, has been done and can not be undone. It can, however, serve as a warning to "let well enough alone," and where the indigenous fish is all that can be desired in game and food qualities to attempt to conserve or increase the supply, as needs be, rather than to introduce others, the possible disastrous effects of which can not always be foreseen. Only a few years ago there were those who stoutly advocated the introduction of white perch into Rangeley Lakes. Fortunately, this was not done, and the suggestion now offered is that no other fish than the trout and salmon be planted in the lakes.

Of the other introduced fishes that have become established, it is doubtful if any are of much harm under present conditions. The hornpout is to some extent addicted to eating young fish and to a great extent to devouring fish eggs when available; but probably it does not frequent the spawning beds of salmon and trout. The pickerel in its many years of existence in Umbagog Lake has shown that it is no menace to the upper lakes and of little or no harm to Umbagog. It has been previously stated in this paper that it is the opinion of the writer that fishing through the ice and plug fishing in the deep holes at other times, in conjunction with the general unsuitableness of the lake, is responsible for the scarcity of trout there and that the pickerel had no appreciable effect on the trout. In fact, the lake is better suited to the pickerel than to almost any other game fish.

Even if numerous in all the lakes the whitefish could be harmful only in a more or less remotely indirect way—that is to say, by its effect upon the ultimate or immediate food supply of some species.

Protective laws are now about as restrictive as present conditions require, the only exception being one relating to plug fishing.[a] The opponents of such a law have advanced as an argument that it would deprive women and children of the privilege of fishing from the shore and piers. A law could be framed, which could be more easily enforced than a general law against bait fishing, that would prohibit fishing in deep water only; that is, those places already known or subsequently discovered where trout and salmon can be caught in that way. Summer plug fishing and winter ice fishing are most potent factors in the depletion of any lake.

The writer believes that young trout and salmon should be planted in those places affected by young fish under natural conditions, as has been previously discussed in this paper. Too often young fish are planted directly in a lake and, as it were, into the waiting maws of predacious fishes. Also, they should be planted at a season when food is abundant, as they have been plentifully fed up to the time of planting, and to liberate them in late fall or early winter is but to subject them to very deficient food conditions. Late spring or early summer affords the most abundant food, especially in those waters where the fish should be planted.

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[a] At the present time there is a general State law (sec. 31, Chap. 33, Rev. Stat.; amended by Chap. 219, Public Laws of 1917) to prohibit advance baiting, a practice which consisted of depositing meat, bones, fish, etc., for the purpose of luring fish to certain localities, also a special law (sec. 19) limiting the number of salmon and trout that can be taken by plug fishing in one day by any person, party or occupants of any one boat or other conveyance, in Richardson, Mooselucmaguntic and Cupsuptic Lakes, and making it unlawful for any person to fish for, take, catch or kill any kind of fish at any time in Rangeley Lake (Oquossoc) by still or "plug" fishing.

APPENDIX.

TABLES OF MEASUREMENTS AND COUNTS ON SPECIMENS OF FISHES FROM RANGELEY LAKES WATERS AND VICINITY.

Tables I to IV and X and XI comprise certain proportional measurements and counts of fin rays, scales, and other structures. Only the extremes of measurements and the averages are given. The proportions are obtained by dividing the length of one part by another. For example: Head in length without caudal, means length of head from tip of snout to posterior margin of opercle into length of fish to base of of the caudal fin. Eye in head refers to the quotient obtained by dividing the length of the head by length of eye, etc. Scales, as 20–107–15, means that there are 20 scales, counting the oblique series from the front of the dorsal to and including the lateral line; 107 from the upper angle of the opercle to the last fully developed scale at base of caudal; and 15 scales from oblique series from lateral line to base of ventral. Pharyngeal teeth 2, 4–4, 2, signifies 2 rows of the designated number of teeth on each side, 4 in the major and 2 in the minor row. Spines in fins are indicated by roman and rays by common numerals, the small letter "i" indicating simple, undivided, or rudimentary rays.

Tables V to IX, inclusive, comprise the actual measurements in millimeters. The distance from tip of snout to base of caudal is also given, so that any system of working out the proportions may be employed. The terms employed are practically the same as in the other tables. The figures indicating the gill rakers give the numbers on each arm of the gill arch and the total.

TABLE I.—PROPORTIONAL MEASUREMENTS AND COUNTS ON FIVE SPECIMENS OF LONG-NOSE SUCKERS (CATOSTOMUS CATOSTOMUS) FROM UMBAGOG LAKE, 1905.

Parts measured.	Range of measurements.	Average.
Total length in millimeters	267–330	289
Depth in length without caudal	4.85–5.11	4.97
Head in length without caudal	4.21–4.47	4.34
Eye in head	6.37–7.11	6.81
Eye in interorbital width	2.75–3.05	2.93
Tip of snout to eye in head	2.11–2.31	2.21
Longest dorsal ray in head	1.33–1.88	1.51
Longest anal ray in head	1.28– 1.61	1 42
Length of pectoral fin in head	1.16– 1.36	1.27
Length of two ventral fins in head	1.64– 1.83	1.71
Number of dorsal rays	i, 10 –i, 11	i, 10.20
Number of anal rays[a]	i, 6 –i, 7	i, 6.60
Scales	20–103 to 110–14 to 16	20–107–15

[a] The males had the shorter anal fins.

TABLE II.—PROPORTIONAL MEASUREMENTS AND COUNTS ON THREE SPECIMENS OF COMMON SUCKER (CATOSTOMUS COMMERSONII), FROM OQUOSSOC LAKE, OCTOBER 17, 1900.

Parts measured.	Range of measurements.	Average.	Parts measured.	Range of measurements.	Average.
Total length in millimeters	147–162	(?)	Length of pectoral fin in head	1.44–1.48	1.46
Depth in length without caudal	4.48–4.76	4.67	Length of ventral fin in head	2.05–2.16	2.13
Head in length without caudal	3.59–3.71	3.64	Number of dorsal rays	12	12
Eye in head	5.29–6.52	5.34	Number of anal rays	7	7
Tip of snout to eye in head	2.05–2.17	2.09	Number of scales in longitudinal series	66	66
Interorbital in head	2.46–2.60	2.52	Number of scales in cross series, dorsal to ventral	18	18
Longest dorsal ray in head	1.50–1.76	1.66			
Longest anal ray in head	1.40–1.68?	1.51?			

TABLE III.—PROPORTIONAL MEASUREMENTS AND COUNTS ON EIGHT SPECIMENS[a] OF CHUB (SEMOTILUS BULLARIS), FROM OQUOSSOC LAKE, OCTOBER 17, 1900.

Parts measured.	Range of measurements.	Average.	Parts measured.	Range of measurements.	Average.
Total length in millimeters	127–187	152	Longest anal ray in head	1.65–1.94	1.79
Head in length without caudal	3.78–4.12	3.93	Length of pectoral in head	1.54–1.73	1.61
Tip of snout to eye without caudal	2.64–3.00	2.75	Length of ventral in head	1.88–2.06	1.94
Eye in head	4.50–5.50	5.11	Number of dorsal rays	8–9	8.12
Interorbital in head	1.81–2.00	1.93	Number of anal rays	7–8	7.12
Maxillary in head	2.66–3.10	2.95	Scales	8 to 9–47 to 50–4 to 5	8.50–49–4.62
Mandible in head	2.42–2.75	2.57	Number of lower pharyngeal teeth	2,4–5,2	2,4–5,2
Longest dorsal ray in head	1.20–1.50	1.40			

[a] Three of the specimens were males.

TABLE IV.—PROPORTIONAL MEASUREMENTS AND COUNTS ON TEN SPECIMENS[a] OF REDFIN (NOTROPIS CORNUTUS), FROM OQUOSSOC LAKE, OCTOBER 17, 1900.

Parts measured.	Range of measurements.	Average.	Parts measured.	Range of measurements.	Average.
Total length in millimeters	76–127	112	Number of dorsal rays	8	8
Depth in length without caudal	3.54–4.55	4.17	Number of anal rays	9	9
Head in length without caudal	4.10–4.55	4.32	Scales in longitudinal series	42	42
Eye in head	3.55–5.00	4.16	Number of lower pharyngeal teeth	2,4–4,2[b]	....
Tip of snout to eye in head	2.50–3.07	2.77			
Longest dorsal ray in head	1.00–1.25	1.13			

[a] Five specimens were males, the others doubtfully females.

[b] Nine specimens uniform; one had teeth 2, 5–4, 2.

TABLE V.—MEASUREMENTS[a] AND COUNTS TAKEN FROM SPECIMENS OF WHITEFISH (COREGONUS CLUPEAFORMIS), FROM UMBAGOG LAKE.

Length to base of caudal.	Length of head.	Greatest depth.	Length of eye.	Length of snout.	Length of maxillary.	Length of mandible.	Width of interorbital.	Depth of head.	Distance from eye to gill opening.	Length of longest dorsal ray.	Length of longest anal ray.	Length of pectoral.	Length of ventral.	Length of longest gill raker.	Number of gill rakers.	Number of scales.	Dorsal-fin formula.	Anal-fin formula.	Sex.
mm.	*mm*	*mm*	*mm.*	*mm.*	*mm*	*mm*	*mm.*	*mm.*	*mm.*	*mm*	*mm.*	*mm*	*mm.*	*mm.*					
312	71	77	15	16	18	26	19.5	34	37.5	48	......	57	......	7	10+17:27 10+18:28	10-78-8	iii, 10	iii, 11	♀
400	87	92	16+	20	22	30	24	42	37.5	60	38	69	66	8.5	10+18:28 11+17:28	10-83-8	iii, 12	iii, 13	♀
310	73	88	15+	19	19	28	20	26.5	38+	53	40	61+	55.5	8.5	10+18:28 10+17:27	10-80-8	iii, 11	iii, 11	♂
330	69	73	15.5	16.5	19	26	19	33	36.5	55	40	55	54	7.5+	10+17:27 10+18:28	10-78-8	iii, 12	iii, 13	♀
370	74	81	15	19.5	19	28	21	36	38.5	57	41.5	61	58.5	7.5	10+19:29 11+19:30	10-86-8	iii, 12	iii, 11	♀
330	73	78	14	18	19	27	19.5	34.5	37	54	......	....	......	7.5	10+18:28 10+19:29	10-83-8	iii, 11	iii, 12	♀
352	74	76	15.5	17	20	29	22.5	......	......	62	42	60	59	9	10+19:29 11+19:30	11-87-9	iii, 11	iii, 11	♂
270	76	62	13	14.5	16	22	16	......	......	45	34	44	44	6	11+18:29 11+18:29	10-84-9	iii, 12	iii, 12	♂

[a] The actual measurements are given in order that anyone desiring to make comparisons may use his own system.

TABLE VI.—MEASUREMENTS AND COUNTS TAKEN FROM SPECIMENS[a] OF BLUEBACK TROUT (SALVELINUS OQUASSA), IN THE UNITED STATES NATIONAL MUSEUM.

Total length.	Lenth to base of caudal.	Head.	Depth.	Eye.	Snout.	Maxillary.	Mandible.	Longest dorsal ray.	Longest anal ray.	Pectoral.	Ventral.	Longest gill raker.	Number of gill rakers.	Number of branchiostegals.	Number of dorsal rays.	Number of anal rays.
mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*				
241	205	41	40	10−	10+	19	25.5	24	....	29	....	3−	9+12:21 9+12:21	9 9	11	11
222	205	40	42	8	10	17.5	23+	25	....	29.5	....	3	8+12:20 6+13:19	9 9	11	11
195	170	37	34	7.5	9	16.5	22	23	....	26	....	....	8+11:19 6+11:17	9 9	11	11
[b] 288	350	78	68	13	22	40	47	50	....	48	....	....	8+13:21 8+12:20	......	11	10

[a] Sex unknown.
[b] Measurements and counts from a breeding female from Kennebago Stream, 1900.

TABLE VII.—MEASUREMENTS AND COUNTS OF LANDLOCKED SALMON (SALMO SEBAGO) FROM UMBAGOG LAKE, 1905.

Total length.	Length without caudal.	Length of head.	Greatest depth.	Distance snout to dorsal.	Base of dorsal.	Dorsal to adipose.	Base of adipose.	Adipose to caudal.	Pectoral to ventral.	Ventral to anal.	Base of anal.	Anal to caudal.	Least depth caudal peduncle.	Longest dorsal ray.	Longest anal ray.	Length of pectoral.	Length of ventral.	Eye.	Snout.	Maxillary.	Mandible.	Interorbital.	Longest gill raker.	Number of gill rakers.	Number of branchiostegals.	Number of scales.	Number of dorsal rays.	Number of anal rays.	Sex.
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.						
425	375	89	.....	171	49	95	16.5	36	117	80	33	43	33	48	39	56	41	13.5	27	42	52	31	6	7+13:20 8+13:21	12 11	21–115–21	11	9	....
403	350	80	.....	155	42	86	11	30	104	83	26.5	41	30	41	37	50	42	13	23	43	47	27	5	8+13:21 8+12:20	10 11	21–115–21	12	9	....
381	340	76	.....	153	39	80	10	31	107	81	27	39	28	42	30	47	38	13.5	20	36	44	27	5	7+11:18 7+12:19	11 12	23–115–21	11	9	....
377	323	73	77	140	40	77	12.5	34	104	75	26	38	27.5	42	32	50	36	12+	20	35	41	26	5	8+13:21 8+13:21	11 12	23–115–21	12	9	♂
390	337	77	72	150	37	84	12	35	107	76	27	40	27	47	35	55	42	12.5	22	36	41	26	6	7+12:19 7+12:19	10 11	23–115–21	11	9	♂

TABLE VIII—MEASUREMENTS AND COUNTS OF LARGE BLUEBACK TROUT (SALVELINUS OQUASSA) TAKEN FROM RANGELEY STREAM, BREEDING FISH IN 1903.

Total length.	Length without caudal.	Length of head.	Greatest depth.	Tip of snout to dorsal fin.	Base of dorsal.	Dorsal to adipose.	Base of adipose.	Adipose to caudal.	Pectoral to ventral.	Ventral to anal.	Base of anal.	Anal to caudal.	Least depth of caudal peduncle.	Longest dorsal ray.	Longest anal ray.	Length of pectoral.	Length of ventral.	Number of branchiostegals.	Longest gill raker.	Number of gill rakers.	Number of dorsal rays.	Number of anal rays.	Number of pores.	Length of eye.	Length of snout.	Length of maxillary.	Length of mandible.	Width of interorbital.	Sex.
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.		mm.					mm.	mm.	mm.	mm.	mm.	
360	313	76	77	144	38	80	4	30	91	70	38	38	27	46	36	50	80	10 9	.....	7+12:19	11	11	136	12	21	39	48	25	♂
368	326	82	75	146	38	86	4.5	30	93	73	36	33	29	52	41	52	44	10 9	5	8+15:23 7+14:21	10	9	.....	12	26	47	54	27	♂
346	308	75	73	134	39	73	5	30	89	69	33	37	25	43	36	48	41	9 9	5	7+12:19 7+13:20	10	10	.....	12	24	46	52	26	♂
381	336	84	75	145	44	81	5	36	94	67	38	37	29	47.5	42	55	48	9 10	3	7+12:19 9+12:21	11	11	136	12	26	49	54	28	♂

TABLE IX.—MEASUREMENTS OF TROUT (SALVELINUS FONTINALIS) TAKEN FROM RANGELEY STREAM, 1904.

Total length.	Length without caudal.	Head.	Depth.	Eye.	Snout.	Maxillary.	Mandible.	Interorbital.	Longest dorsal ray.	Longest anal ray.	Pectoral.	Ventral.	Longest gill raker.	Number of gill rakers.	Distance adipose to caudal.	Distance anal to caudal.	Least depth of caudal peduncle.	Number of pores.	Number of dorsal rays.	Number of anal rays.	Sex.
mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*		*mm.*	*mm.*	*mm.*				
438	390	95	101	13.5	26	55	67	32.5	45	51	59	48	5	7+11 8+11	39	42	42	115	i, 9	ii, 19	♀
432	390	93	87	12	28	60	71	33	53	48	57	46	5	8+11 7+13	40	41	36	125	i, 9	ii, 8	♀
445	387	112	95	17	36	79	96	35	60	65	70	60	5	7+10 7+10	38	35	39	.....	11	8	♂
390	356	100	83	14	34	72	83	32	47	50	58	49	5	7+10 7+11	31	31	36	115	i, 10	8	♂
374	335	93	82	13	28	61	70	27	53	51	58	45	6	6+10 8+11	35	32	34	115	i, 9	7	♂

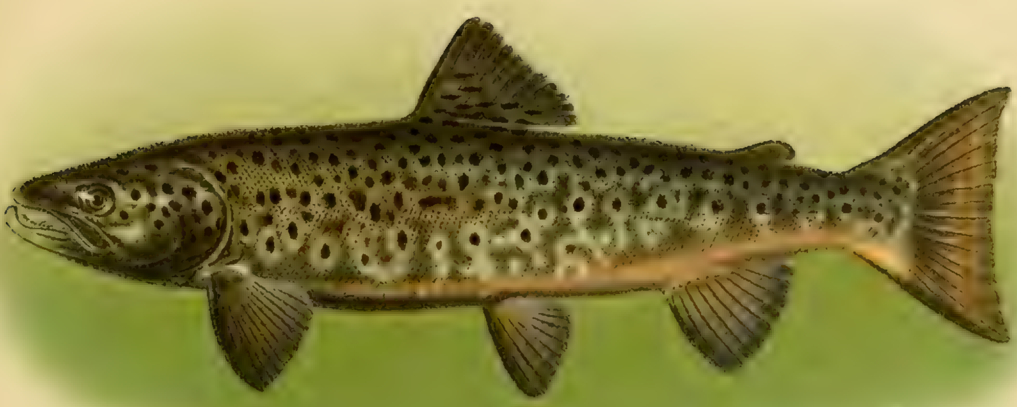
TABLE X.—PROPORTIONAL MEASUREMENTS AND COUNTS OF TWO PICKEREL[a] (ESOX RETICULATUS), EACH WEIGHING ABOUT 4 POUNDS, FROM UMBAGOG LAKE, JULY 24, 1905.

Parts measured.	No. 1.	No. 2.	Parts measured.	No. 1.	No. 2.
Total length in millimeters	584	603	Width of snout—maxillary width in head	2.93	3.24
			Longest dorsal ray in head	2.40	2.71
Depth in length without caudal	5.06	5.03	Longest anal ray in head	2.39	2.67
Head in length without caudal	3.44	3.62			
Eye in head	10.44	10.11	Number of dorsal rays	iii, 15	iii, 14
Tip of snout to eye in head	2.18	2.16	Number of anal rays	iii, 14	iii, 14
Maxillary in head	1.87	1.97	Number of scales in longitudinal series	135	134
Mandible in head	1.46	1.42	Number of rows of scales on cheek	10	12
Eye in interorbital width	2.00	2.00			

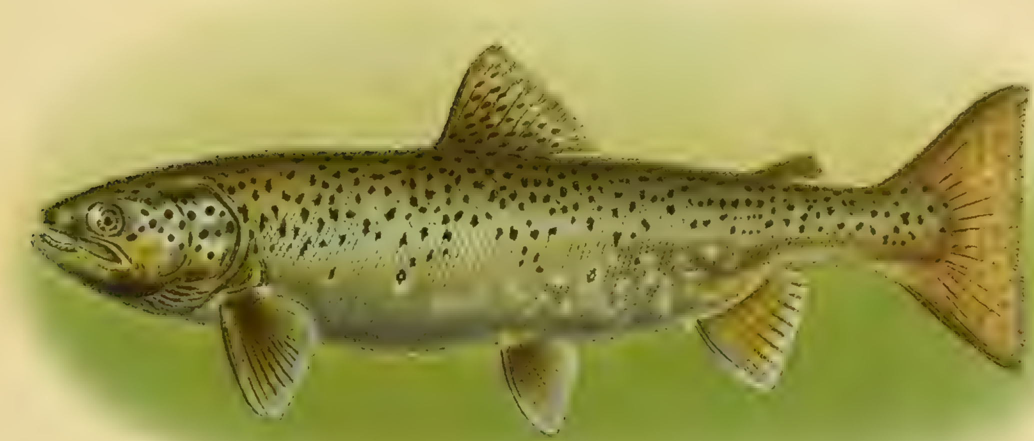
[a] The color was green and gold, finely reticulated with black.

TABLE XI.—PROPORTIONAL MEASUREMENTS AND COUNTS OF SIX SPECIMENS OF MILLER'S THUMB (COTTUS GRACILIS), FROM BEAR RIVER, NEWRY, ME.

Parts measured.	Range of measurements.	Average.	Parts measured.	Range of measurements.	Average.
Total length in millimeters	25–76	38	Longest dorsal ray in head	1.78–2.35	2.05
			Length of pectoral in head	.89–1.11	.99
Depth in length without caudal	4.91–5.60	5.23	Length of ventral in head	1.29–1.50	1.39
Eye in head	3.00–4.00	3.76			
Tip of snout to eye in head	3.40–5.35	4.00	Number of dorsal rays	vii, 16–viii, 17	vii, ⅔, 16⅙
Maxillary in head	2.25–2.50	2.38	Number of anal rays	11–14	11⅔
Mandible in head	1.89–2.22	2.15	Number of ventral rays	3	3
Interorbital in head	8–10	8.87			
Longest dorsal spine in head	3.00–3.90	3.61			

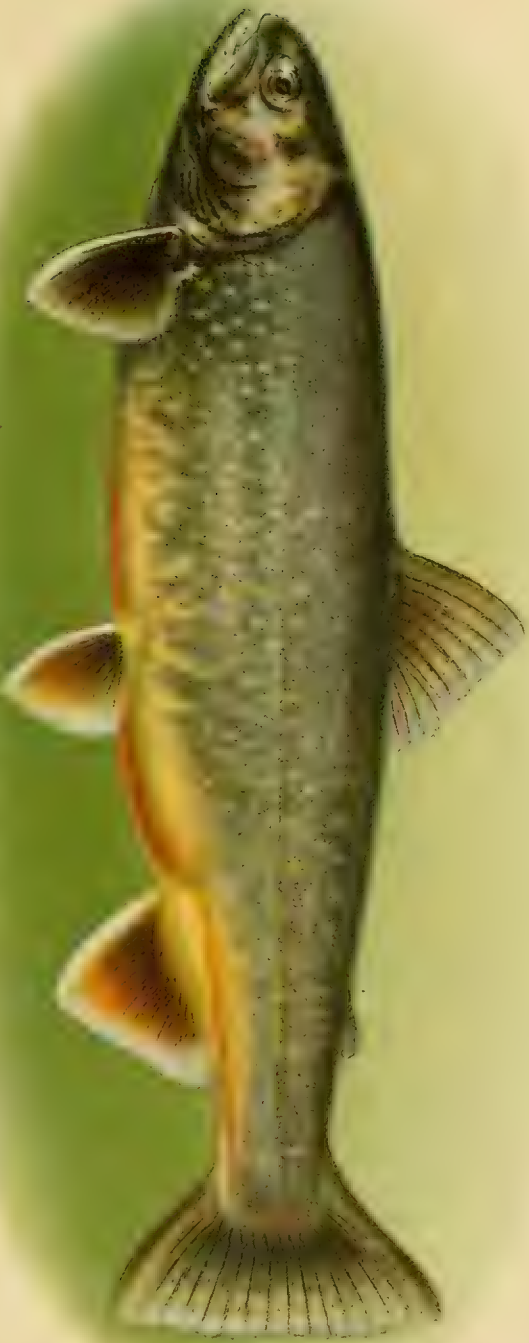


Landlocked salmon, *Salmo sebago* (Girard). Breeding male, 19 inches long. From Rangeley Stream, Oquossoc, Me.



Landlocked salmon, *Salmo sebago* (Girard). Nearly ripe female, 19 inches long. From Rangeley Stream, Oquossoc, Me.

BREUKER & KESSLER CO. PHILA



Oquassa trout; blueback trout; quasky, *Salvelinus oquassa* (Girard). Breeding female, 15 inches long. From Rangeley Stream, Oquossoc, Me.

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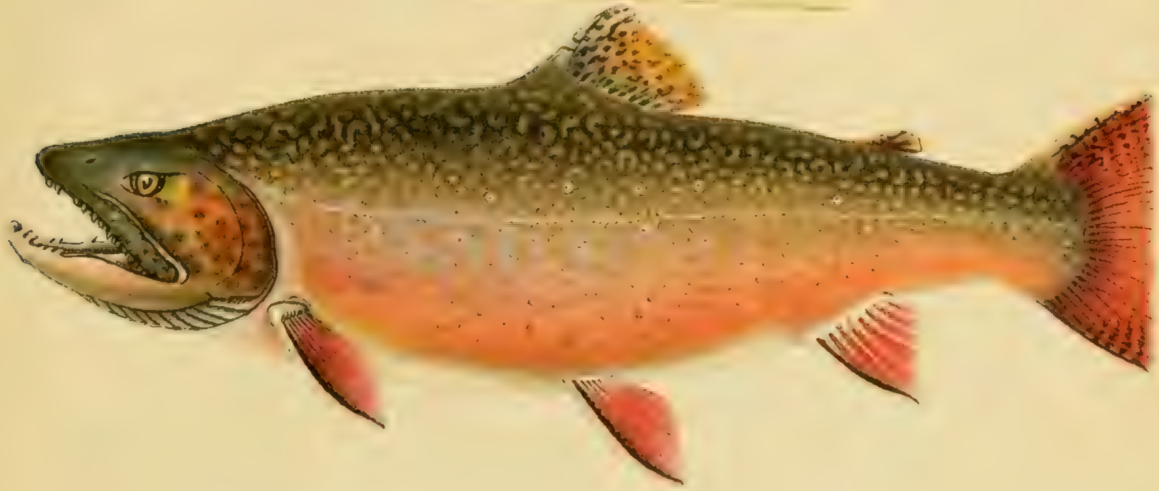
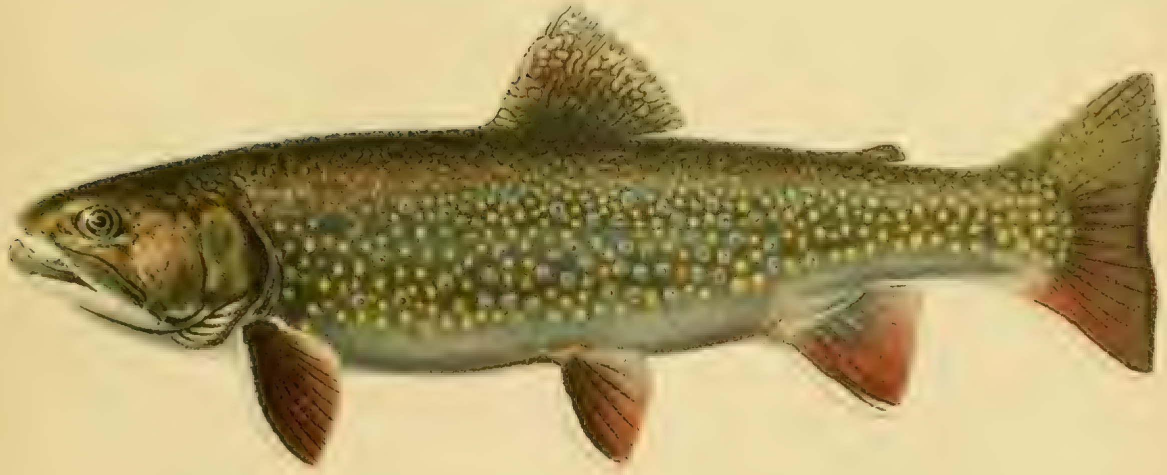
Upper S. fontinalis is
drawn by
Walter H. Rich
and lower S. fontinalis
was drawn by
Charles B. Hudson



Brook trout; speckled trout, *Salvelinus fontinalis* (Mitchell). Nearly ripe male, 6¾ pounds. From Parmacheenee Falls, Magalloway River, Me.



Brook trout; speckled trout, *Salvelinus fontinalis* (Mitchell). A female, 16.5 inches long. From Rangeley Stream, Oquossoc, Me.

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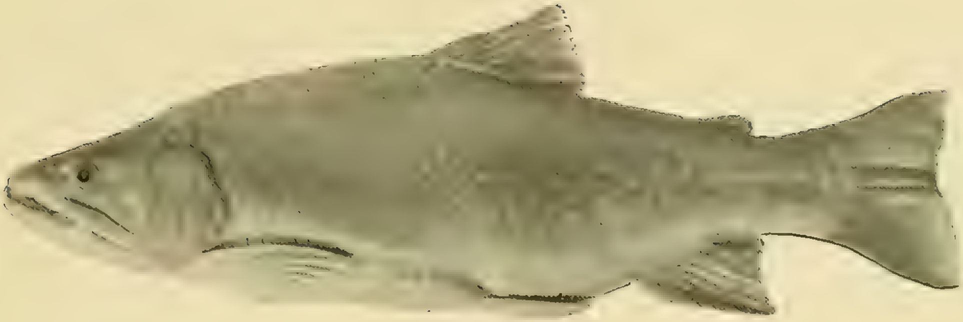
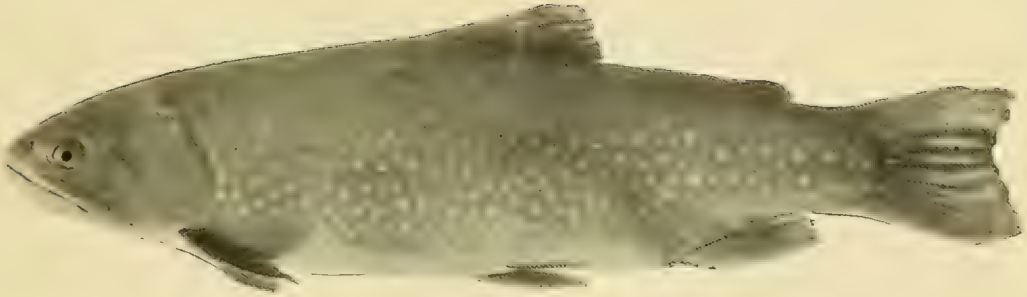
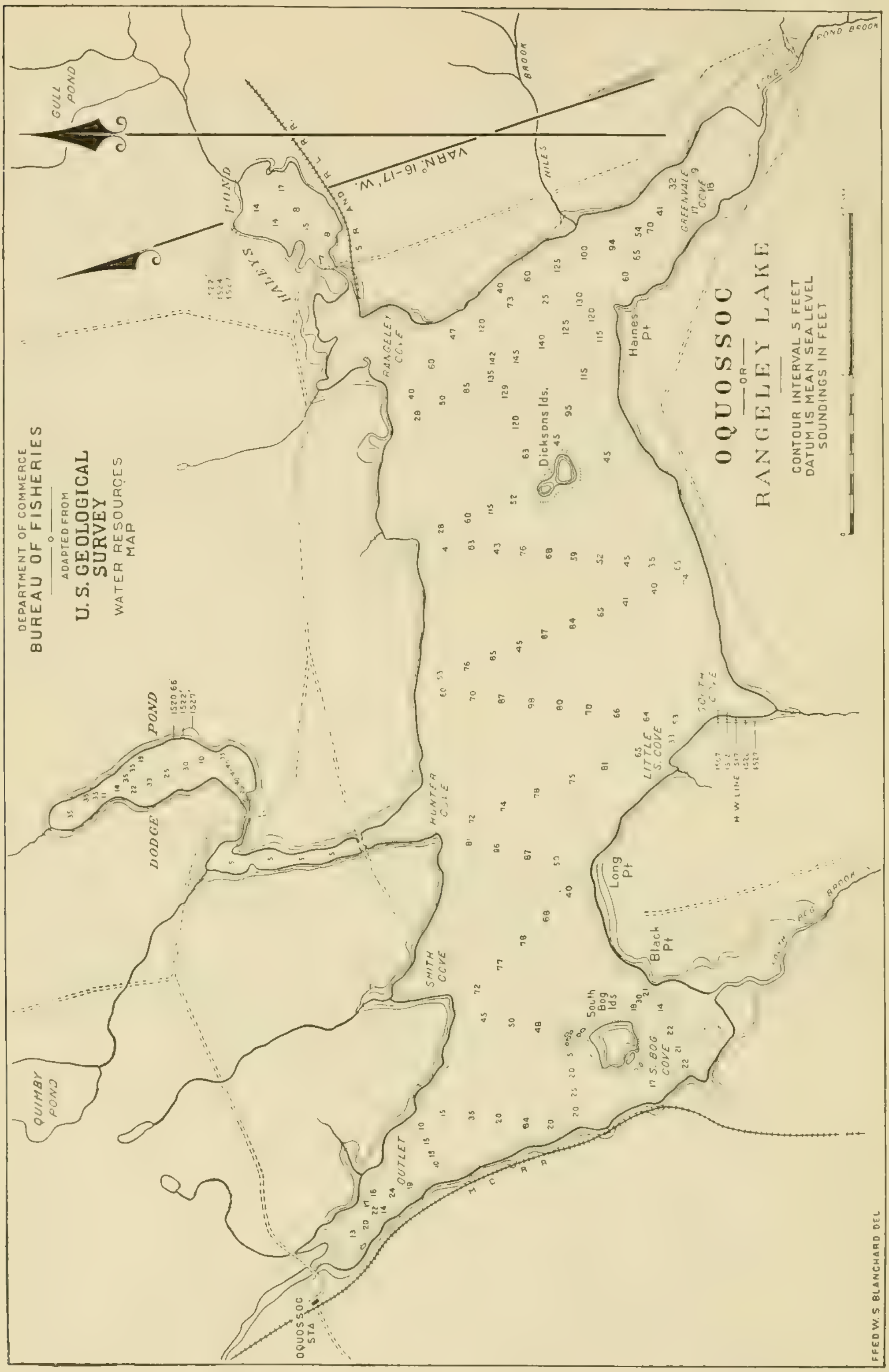


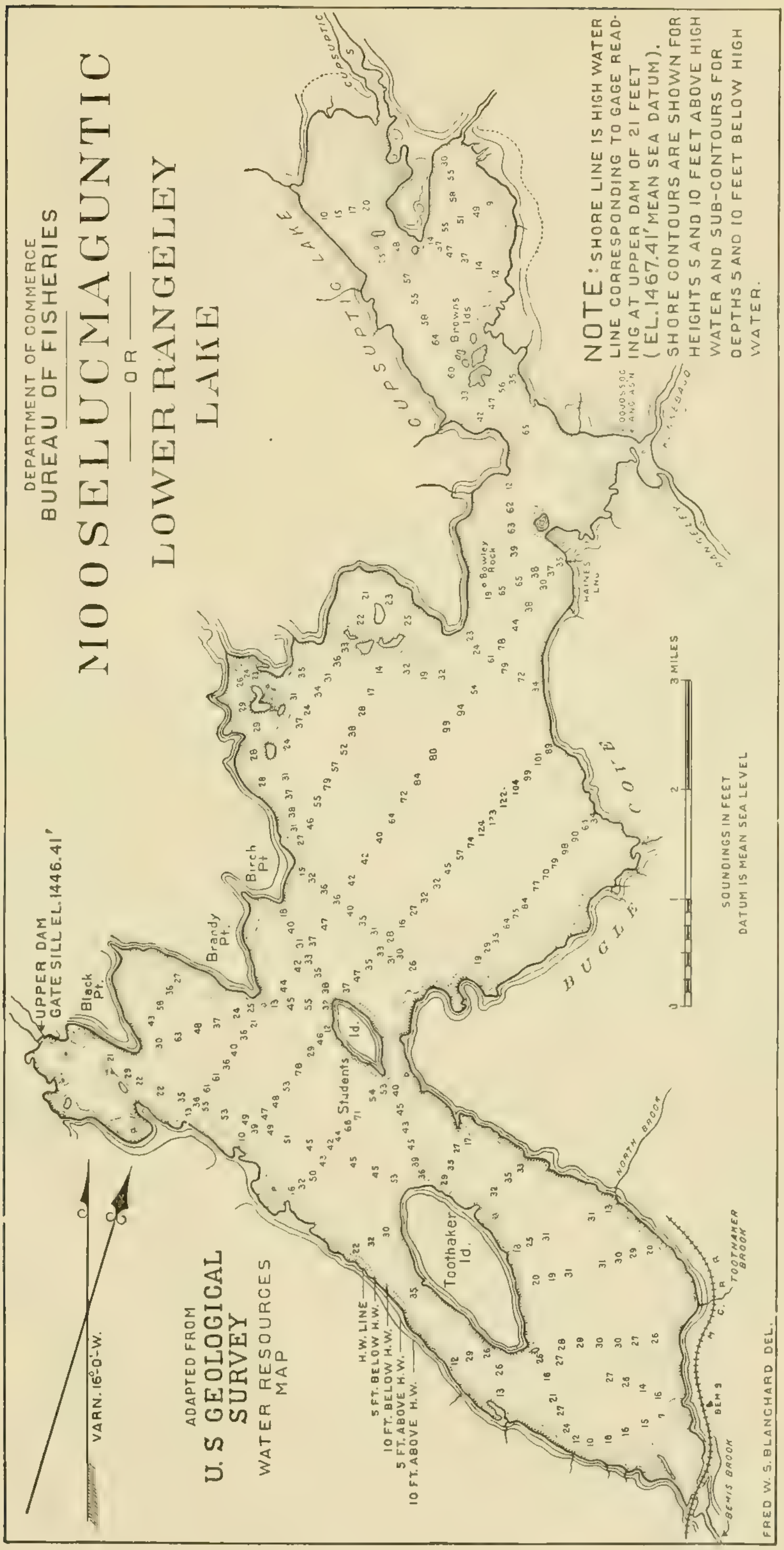
Male.

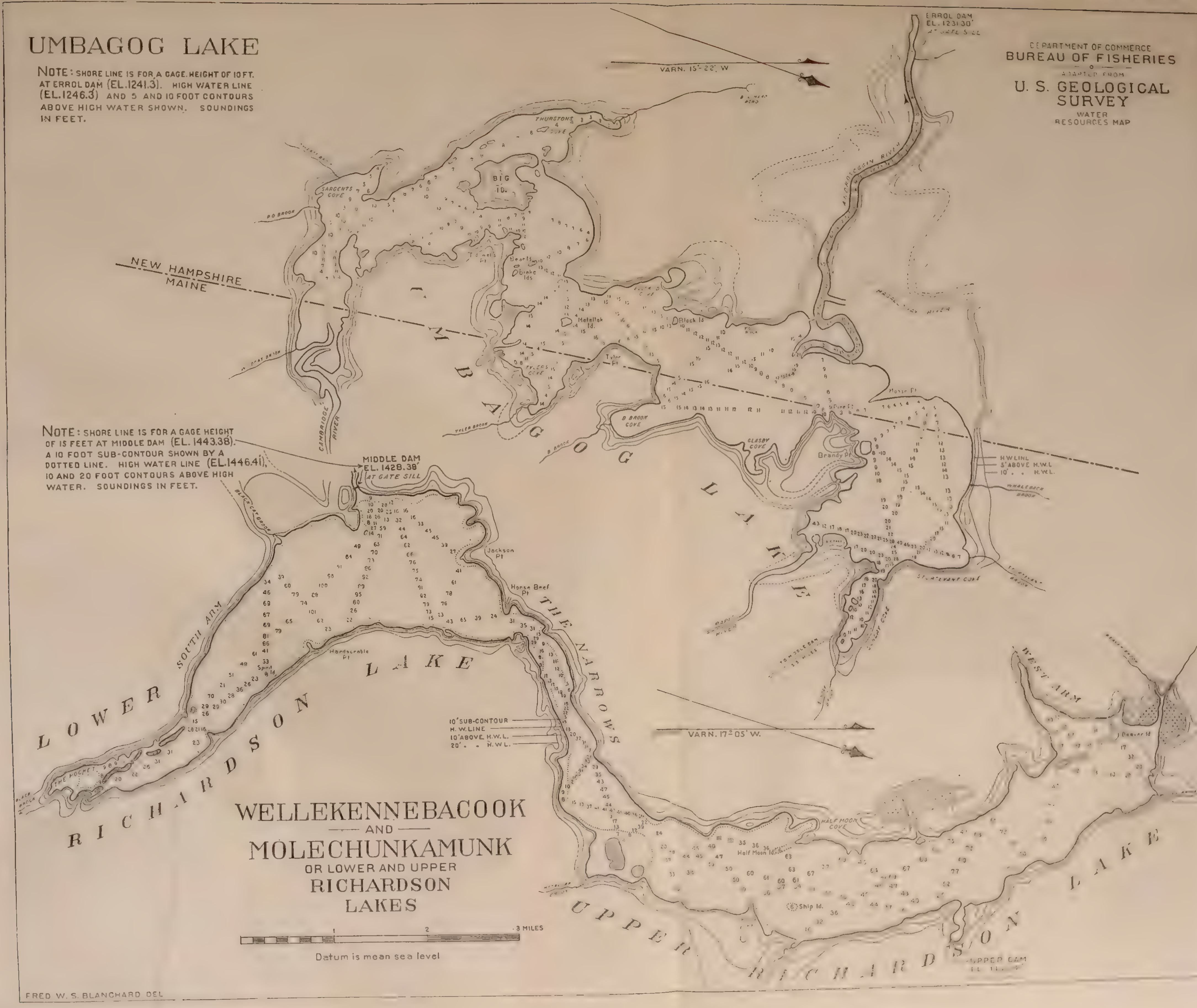


Female.

Brook trout, *Salvelinus fontinalis*, in breeding condition.


DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
ADAPTED FROM
U.S. GEOLOGICAL SURVEY
WATER RESOURCES MAP
OQUOSSOC
OR
RANGELEY LAKE
CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL
SOUNDINGS IN FEET
VAR. 16-17° W.
GULL POND
HALEYS POND
DODGE POND
QUIMBY POND
RANGELEY COVE
HUNTER COVE
SMITH COVE
OUTLET
Dicksons Ids.
Haines Pt
GREENVALE COVE
LONG POND BROOK
NILES BROOK
SOUTH COVE
LITTLE S. COVE
Long Pt
Black Pt
South Bog Ids
S. BOG COVE
SOUTH BOG BROOK
H W LINE
OQUOSSOC STA
FRED W. S. BLANCHARD DEL


DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
MOOSELUCMAGUNTIC
OR
LOWER RANGELEY
LAKE
ADAPTED FROM
U. S GEOLOGICAL SURVEY
WATER RESOURCES
MAP
VARN. 16°-0'-W.
UPPER DAM
GATE SILL EL. 1446.41'
Black Pt.
Brandy Pt.
Birch Pt.
Students Id.
Toothaker Id.
Bowley Rock
Browns Ids
HAINES LND
CUPSUPTIC LAKE
CUPSUPTIC
BUGLE COVE
NORTH BROOK
TOOTHAKER BROOK
BEMIS BROOK
BEMIS
R. R.
M. C.
RANGELEY
H.W. LINE
5 FT. BELOW H.W.
10 FT. BELOW H.W.
5 FT. ABOVE H.W.
10 FT. ABOVE H.W.
0
1
2
3 MILES
SOUNDINGS IN FEET
DATUM IS MEAN SEA LEVEL
NOTE: SHORE LINE IS HIGH WATER LINE CORRESPONDING TO GAGE READING AT UPPER DAM OF 21 FEET (EL. 1467.41' MEAN SEA DATUM). SHORE CONTOURS ARE SHOWN FOR HEIGHTS 5 AND 10 FEET ABOVE HIGH WATER AND SUB-CONTOURS FOR DEPTHS 5 AND 10 FEET BELOW HIGH WATER.
FRED W. S. BLANCHARD DEL.


UMBAGOG LAKE
NOTE: SHORE LINE IS FOR A GAGE HEIGHT OF 10 FT. AT ERROL DAM (EL. 1241.3). HIGH WATER LINE (EL. 1246.3) AND 5 AND 10 FOOT CONTOURS ABOVE HIGH WATER SHOWN. SOUNDINGS IN FEET.
DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
ADAPTED FROM
U. S. GEOLOGICAL SURVEY
WATER RESOURCES MAP
ERROL DAM
EL. 1231.30'
AT GATE SILL
VARN. 15°-22' W
ANDROSCOGGIN RIVER
MAGALLOWAY RIVER
THURSTONS COVE
SARGENTS COVE
BIG ID.
Pearls Blake Ids
Metallak Id.
Black Id.
Tyler Pt
TYLERS COVE
TYLER BROOM
B BROOK COVE
GLASBY COVE
Brandy Pt
Pine Pt
Moose Pt
NEW HAMPSHIRE
MAINE
CAMBRIDGE RIVER
U M B A G O G L A K E
H.W. LINE
5' ABOVE H.W.L.
10' " H.W.L.
WHALEBACK BROOK
STURTEVANT COVE
RAPID RIVER
NOTE: SHORE LINE IS FOR A GAGE HEIGHT OF 15 FEET AT MIDDLE DAM (EL. 1443.38). A 10 FOOT SUB-CONTOUR SHOWN BY A DOTTED LINE. HIGH WATER LINE (EL. 1446.41), 10 AND 20 FOOT CONTOURS ABOVE HIGH WATER. SOUNDINGS IN FEET.
MIDDLE DAM
EL. 1428.38'
AT GATE SILL
BLACK CAT BROOK
Jackson Pt
Horse Beef Pt
THE NARROWS
SOUTH ARM
Hardscrabble Pt
Spirit Id
THE POCKET
LOWER RICHARDSON LAKE
10' SUB-CONTOUR
H. W. LINE
10' ABOVE H.W.L.
20' " H.W.L.
VARN. 17°05' W.
WEST ARM
Beaver Id
HALF MOON COVE
Half Moon Ids
Ship Id.
UPPER RICHARDSON LAKE
UPPER DAM
WELLEKENNEBACOOK
AND
MOLECHUNKAMUNK
OR LOWER AND UPPER
RICHARDSON
LAKES
1
2
3 MILES
Datum is mean sea level
FRED W. S. BLANCHARD DEL

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